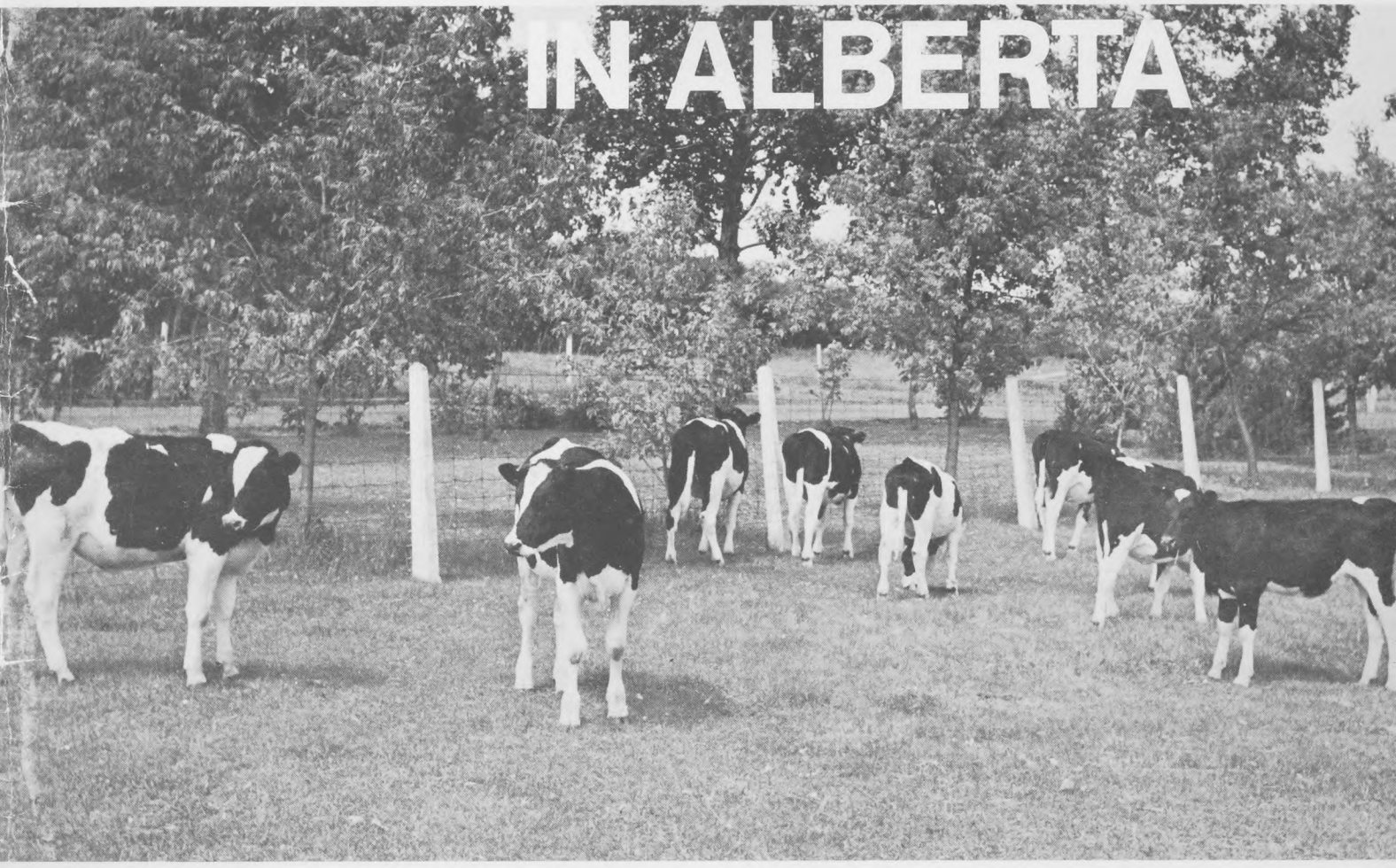
DAIRY CATTLE PRODUCTION IN ALBERTA



DEPARTMENT OF ANIMAL SCIENCE
FACULTY OF AGRICULTURE

THE UNIVERSITY OF ALBERTA

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DAIRY CATTLE PRODUCTION IN ALBERTA

By

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INTRODUCTION

Dairying is one of the major agricultural industries in Alberta. In 1968, the farm value of milk and milk products produced in Alberta was almost $63,000,000. During that year 215,000 cows were kept for dairy purposes. Many areas of the province are well suited to dairying and it seems that factors limiting expansion of the industry are the shortage of skilled farm labour and a market for dairy products, not the production potential of Alberta farms.

The quality of Alberta dairy products is high as shown by grading statistics and by the record winnings of butter samples at dairy shows. Fluid milk supplies in the province have an excellent record of good sanitation, and prices to the consumer are among the lowest on the continent.

The feeding and management of dairy cattle have been improving steadily. The average production per cow is almost double what it was 20 years ago, but at approximately 7,200 lb. per year is still not high enough to be profitable under the price conditions that exist today. Compare the overall average of 7,236 lb. to the average production of 11,728 lb. by the 20,922 cows tested by the Cow Testing Service of the provincial Department of Agriculture. This represents the kind of improvement possible for Alberta producers under practical conditions if improved systems of feeding, breeding and management are adopted.

Dairying, like many other agricultural industries, is experiencing a period of high costs and low income. Per capita consumption of dairy products is decreasing and serious competition for major dairy markets is growing. Under these economic conditions it is imperative that dairy farmers improve their methods to increase production per cow and cut costs so that they are able to maintain a good supply of high quality dairy products, which are so essential to the health of our nation, as well as to provide a fair and equitable income for themselves and their families.

This bulletin is intended to supply information upon which sound decisions can be made as to the most efficient and economical way to feed and manage dairy cattle. Only those factors which affect the health of the animals, the production of milk or the quality of the product will be presented. Information concerning the management of the business or the economics of dairying is beyond the scope of this bulletin.

Requirements of a Dairy Enterprise

Producing milk is one of the most exacting and demanding of the farm enterprises. The producer is dealing with very delicate functions of the animal body and with highly specialized and temperamental animals. The need of regularity, thoroughness and responsibility is essential and continuous.

The product is a perishable and easily contaminated food. Consumers and processors demand care and cleanliness in the production of milk. Failure to maintain the proper standards can have serious effects.

In order that milk may be produced under conditions acceptable to the consumer and processor, the capital required for the establishment of a dairy herd is large compared to other enterprises. Livestock, labor and feed costs are also comparatively higher for dairy production. Because such large sums are invested and expenses are so high, the business requires very careful financial management.

Characteristics of a Profitable Cow

High Production

Since maintenance costs and overhead charges are almost the same for each cow regardless of her level of production, the more a cow produces the more profit she brings. Dairymen should use every economical method at their disposal to increase production per cow in order to reduce the cost of production per 100 lb. of milk.

Regular Reproduction

To produce a maximum amount of high-quality milk, a cow must calve regularly at intervals of about 12 months. Thousands of cows are lost to the dairy industry and many productive days per cow are lost from failure to breed regularly. Most breeding problems can be controlled by careful feeding and management. Efficient, regular and normal reproduction are necessary in a successful dairy herd.

Longevity

Whether cows are raised or purchased, it is costly to replace a cow in the milking line. The profit of the first 2 or 3 lactations of even heavy milkers covers only the cost of raising or buying the cow. Only 4 to 5 years of milk production can be expected of the average cow in the dairy herd. Management practices which increase the productive life of cattle are very profitable.

Health

Sick animals are a source of expense and economic loss. Money spent to prevent disease is well invested.

Temperament

A profitable cow is a good feeder. She has a gentle, sensible temperament when being milked and handled and is an easy milker.

Fundamentals of Dairy Cattle Feeding

By

C. M. GRIEVE

Within the limits of the inherited potential of the cow, the milk she produces depends largely on the amount and kind of feed she receives. Proper and economical feeding is a good way to cut costs and improve production.

WHAT NUTRIENTS SHOULD FEED SUPPLY?

The "nutrients" or the materials supplied by the ration that are necessary for the cow are: energy, protein, water, minerals and vitamins.

Energy

This is not a particular substance but is supplied by many materials such as starch, fat and protein. The available energy content of a feed may be expressed as total digestible nutrients (T.D.N.) or digestible energy (D.E.). Energy supplies the power for breathing, heart beat and for life itself.

In addition to the energy necessary for maintenance of body processes, the dairy cow must receive sufficient energy in her feed to supply the energy contained in milk. The energy content of milk varies with its fat content.

The most common nutritional deficiency in our dairy rations is lack of energy. It is quite common for cows to be producing below their capacity simply because they are not being fed enough. Energy is most likely to be lacking when:

1. weathered, mature or damaged hay is fed,
2. the hay or silage is not palatable to the cows,
3. pastures are dry, mature or scanty,
4. inadequate amounts of grain and supplement are being fed, and
5. inadequate time is allowed for grazing or feeding.

Protein

Proteins are complex compounds containing nitrogen. Most of the tissues of the body are composed of protein. Muscles, organs, skin, hair, horns, hooves and even a part of the bones are protein. Not only is protein the main structural material in the animal but the enzymes by which the animal digests its food and uses its energy supply are also protein. Protein is needed in the ration to supply material for the growth of new tissues, to replace and repair older tissues and to supply that secreted in milk, which contains about 3.5% protein.

Protein deficiencies are most likely to occur when non-legume roughages are fed exclusively and when low-protein grains are used. Cows on dry, mature pasture may also be deficient in this nutrient.

Deficiencies of energy or protein which usually occur under practical conditions are not likely to affect adversely the apparent health or normal functions of the animal, but are manifest in performance lower than the potential of the animal.

Water

Water is essential for all forms of life. The animal body contains more than 50% and milk over 80% water. Although water is not usually considered as a component of feeds, most dry feeds contain 5 to 20% water. Experiments at The University of Alberta showed that milking cows consumed between 3½ and 4½ gallons of water for each gallon of milk produced. High-producing cows consumed as much as 20 gallons of water daily.

Water consumption greatly influences the amount of milk produced by a cow. In the above experiments, cows with access to water at all times consumed almost 8% more water and produced about 6% more milk than cows watered twice daily. When cows are required to drink under unfavorable circumstances, to consume only ice-cold water, or are allowed access to water only at infrequent intervals, they will not consume sufficient water to produce up to their potential. If water is not available in the barn, the outdoor water trough should be sheltered and a water heater used to raise the temperature high enough to enable cows to consume a maximum quantity. Cows should be allowed to drink more than once or twice a day. Adequate watering facilities are a very sound investment.

Minerals

This class of nutrients is not confined to materials contained in rocks. In fact, most of the minerals consumed by an animal are in the plant and and animal products in the feed. Minerals have different functions which may be classified roughly into three main groups.

1. Structural—minerals such as calcium, phosphorus and magnesium make up a large part of the skeleton and teeth of the animal.
2. Control of body fluids—the amounts and distribution of minerals such as sodium and potassium control the movement and use of body fluids.
3. Catalytic—a catalyst is a material which, in very small amounts, speeds up a chemical process. The catalyst is not used up in the process. Many minerals speed up or assist body processes. For example, iron is necessary in the blood for carrying oxygen, copper is needed for blood formation and phosphorus aids muscle contraction. These processes require specific minerals but usually only in very minute quantities.

The minerals that must be considered in dairy cattle feeding are:

1. *Salt* (sodium chloride) should always be supplied to all farm animals. Common dairy feeds do not contain enough salt to support growth and lactation. If salt is not fed, the body stores are gradually depleted until the animal suddenly suffers a complete collapse.

2. *Calcium* is the major structural mineral in the body. Bones and teeth contain large amounts of calcium. A high-producing cow can secrete 0.1 lb. of calcium in her milk every day. Calcium is most likely to be deficient when legume hay is not being used.

3. *Phosphorus* is associated with calcium in bones and teeth and is present in large quantities in milk. It is one of the most vital minerals and is associated with almost every body process. A deficiency is most likely to occur when cows receive high levels of roughage.

4. *Iodine* is lacking in many areas of Alberta. This element is necessary for the proper function of the thyroid gland which affects growth, reproduction and lactation. Deficiencies are usually observed at calving. Weak, deformed and perhaps hairless calves are dropped by deficient mothers. Mortality is high.

Iodine is usually given as iodized salt. This is very effective in preventing deficiencies.

5. *Cobalt* is necessary for many processes in the body including the formation of red blood cells. There are a few deficient areas in the province, although no frank deficiencies in dairy cattle have been observed. Cobaltized-iodized salt is a very satisfactory and inexpensive source of cobalt for livestock.

Vitamins

These are relatively simple substances which the animal cannot manufacture but which are required in small amounts for important reactions in the body. There are two main groups of vitamins, fat-soluble and water-soluble. The fat-soluble vitamins can be stored in the body if intake is in excess of requirements while the water-soluble vitamins cannot be stored but must be supplied constantly. Water-soluble vitamins are not required in the diet of mature dairy cows because the bacteria in the rumen synthesize these vitamins. Dairy cows do require some of the fat-soluble vitamins in their ration.

1. *Vitamin A* is necessary for the maintenance of the health of tissues on the surface of the eye, digestive tract, reproductive tract and respiratory tract. It is also required for growth, including that of bones, and is involved in dim-light vision. Because this vitamin supports so many vital functions, the obvious deficiency symptoms may vary considerably. Eye lesions, scours, reproductive failure, night blindness, permanent blindness, pneumonia and many other conditions can arise from a vitamin A deficiency. Such conditions, however, can also have other causes such as infectious disease. This makes diagnosis of vitamin A deficiency very difficult.

Vitamin A does not occur as such in plant material but as a yellow pigment called carotene. Carotene is converted by the animal to colorless vitamin A. Factors such as high levels of nitrates may influence the efficiency of utilization of carotene and hence the supply of vitamin A available to the animal.

Both carotene and vitamin A are destroyed by oxidation. Hay loses some of its vitamin A potency during curing and loses most of it if allowed to mature or become weathered and leached. Hay also loses some of its vitamin A activity during storage. Well-made silage retains considerably more vitamin A activity during storage than does hay.

Since the presence of minerals such as iodine, iron and copper promote oxidation of vitamin A or carotene, a stabilized vitamin preparation must be used if vitamin A is to be mixed with minerals or with feeds that contain minerals.

2. *Vitamin D* is necessary for the use of calcium and phosphorus by the animal. A deficiency affects bone causing deformation in the young and weakness in the old animal. Vitamin D is supplied to the animal in the feed or by the action of sunlight on substances in the animal's body.

Growing plants contain no vitamin D, but dead-plant tissues can be irradiated by sunlight to form some of this vitamin. Pasture and silage contain slight amounts of dead leaves, broken stems, etc. Sun-cured hay usually contains considerable quan-

tities of vitamin D but barn-cured hay would contain little more than silage.

Deficiencies seldom occur in mature cows but have been observed in young calves raised indoors on deficient rations.

3. *Vitamin E* is required by dairy cattle, but natural feedstuffs contain ample quantities for mature animals under practical conditions. Only with very carefully controlled experimental conditions can a vitamin E deficiency be produced in mature cattle. Deficient animals usually die from heart failure. Reproduction is not affected. The use of vitamin E products is of questionable use in treating reproductive difficulties in dairy cattle.

Young calves have been shown to suffer from a vitamin E deficiency known as muscular dystrophy or white muscle disease. Not all cases of this disease are caused by vitamin E deficiency. Selenium deficiency and other factors may be involved.

Under Alberta conditions it is highly unlikely that a vitamin E deficiency would develop.

WHAT NUTRIENTS DO ALBERTA FEEDS SUPPLY?

It is desirable to base livestock rations on homegrown or locally available feeds. The overall nutritional value, the major nutrients that are supplied by these feeds, and the nutrients that are likely to be deficient should be considered.

Feeds are divided roughly into two classes — roughages and concentrates. A feed high in fiber and low in energy is a roughage and one low in fiber and high in energy is a concentrate. Some use the term "concentrate" to mean commercially prepared protein supplements only. However, any low-fiber, high-energy feed including farm grain is properly called a concentrate.

Roughages

Hay, silage and pasture are roughages. These feeds form the basis of dairy feeding operations in Alberta. Concentrates and supplements are fed to supply the nutrients which are not supplied by the roughage-feeding program. Roughage is important because:

1. it supplies a large proportion of the nutrients required for dairy cattle at a relatively low cost;
2. a roughage program is highly desirable from the standpoint of soil conservation and land use; and
3. only ruminant animals can convert the large amount of nutrients present in roughage into foods suitable for human consumption.

No type of feed is as variable as roughage. Not only is there great variability in the type of material used for roughage, but during the process of curing, preparing or storing this material it may undergo chemical and physical changes which greatly alter its feeding value. The nutrient content of roughage, particularly hay, is affected by the following conditions.

1. Maturity of the crop. A young, rapidly growing plant is a rich source of most of the nutrients required for dairy cattle. As the crop begins to mature its nutritive value drops very rapidly and, even though the volume of dry matter rapidly increases at this time, the utlimate benefit to the producer is lowered. Experiments at The University of Alberta have shown that dry matter yields of an alfalfa-bromegrass mixture increased 69% from the early-bud to late-bloom stages of maturity of the alfalfa, whereas the yield of digestible dry matter increased only 12% over the same period and decreased 11% between the mid-bloom and late-bloom stages. In general, the greatest value is realized if alfalfa is harvested at 1/10 to 1/8 bloom, red clover at full bloom, grasses shortly before blooming and cereals in the early dough stage.
2. Leaf loss. Leaves are very much richer in nutrients than are stems. If hay is handled so that leaves are lost during the harvesting period the quality of the roughage will be greatly reduced.
3. Leaching. Experiments at the University of Alberta have shown that as much as 1/3 of the dry matter, over 1/3 of the protein and almost 2/3 of the minerals of a forage are readily soluble in water. If cut forages are exposed to rain, these valuable nutrients are quickly lost.
4. Fermentation. Both hay and silage undergo a fermentation wherein some of the nutrients are lost. These feeds should be harvested under conditions in which they can dry or cure rapidly in order to reduce this loss.
5. Molding. Hay that is too wet and silage that is too dry are susceptible to invasion by many molds. Molds waste nutrients, are unpalatable to stock and, in a few cases, may even be harmful to the health of animals.

Hay

Hay is the most commonly fed roughage in Alberta. This feed is usually very susceptible to nutrient loss and damage. In general, hays are low in moisture, high in calcium, carotene and vitamin D but fairly low in phosphorus. The protein content

of hay varies greatly. Good hay contains about 2/3 as much T.D.N. or D.E. as does grain.

Legume hays. A program based on legume crops is a sound one for any dairy enterprise. Legumes usually contain more protein, much more calcium and more carotene than do other roughages. In addition to their superior nutritional value, legumes are valuable in the conservation of soil resources. While legume crops make excellent hay they are generally more difficult to cure properly than are grass hays. There is greater danger of loss of leaf, and the nutritive value of legumes decreases more rapidly with maturity than does that of grass hays. Well-cured legume hays are highly palatable and are very desirable feeds for dairy cattle.

Grass hays. The grass hays most common in Alberta are brome, timothy, creeping red fescue, crested wheat grass, red top, slender wheat grass (western rye) and reed canary grass. Each is adapted to a particular set of conditions, moisture supply being the chief factor which determines the locality in which they will thrive. Only the highest quality best-preserved grass hays contain enough protein to support high milk production. Most grass hays are somewhat deficient in this nutrient. The amount of calcium in grass hays is usually only border-line for milking cattle. Phosphorus is almost universally deficient in grass hays. The carotene content of these feeds is usually considerably lower at the time the crop is harvested than is the carotene content of legumes. However, the carotene content of both legume and non-legume hay depends more on the treatment of the forage during curing and storage than it does upon the initial content.

Mixed hay crops are desirable. The feeding of more than one hay adds variety to the ration and often provides a more suitable supply of nutrients. Mixed-hay crops usually give greater yields than do those composed of a single species. It is desirable that at least one grass and one legume be sown, the kinds being carefully chosen to suit the climatic and soil conditions. Suitable hay mixtures are described in Table 1.

TABLE 1

PASTURE AND HAY MIXTURES SUGGESTED BY THE ALBERTA FORAGE CROPS ADVISORY COMMITEE

For Pasture

Mixture	*lb. seed/acre*	*Adaptation*
1. Rambler or Roamer alfalfa	1-2	For all but the drier parts of the province.
Carlton bromegrass	6	
Boreal creeping red fescue	2-3	
2. Rambler or Roamer alfalfa	2-3	Zones 2 and 3.
Carlton bromegrass or Greenleaf pubescent wheatgrass	8	
3. Rambler or Roamer alfalfa	2-3	Zones 2 and 3.
Summit or Nordan crested wheatgrass	3	
Carlton bromegrass or Greenleaf pubescent wheatgrass	6	
4. Nordan or Summit crested wheatgrass or Sawki Russian wild-rye	6	Driest areas.
Rambler or Roamer alfalfa	1	
5. Carlton bromegrass or Greenleaf pubescent wheatgrass	12	Short-term pasture under irrigation.
Beaver or Roamer alfalfa	2	
6. Carlton bromegrass	8	Long-term pasture under irrigation.
Boreal creeping red fescue	5	
Chinook orchardgrass	5	
Merit white clover	2	

For Pasture or Hay

1. No. 1 pasture mixture	—	For all but drier parts of the province.
2. Rambler, Roamer, Beaver or Ladak alfalfa	3	For zones 2 and 3 where moisture conditions are variable.
Carlton bromegrass or Greenleaf pubescent wheatgrass	5	
Summit or Nordan crested wheatgrass	3	
3. Aurora alsike clover	2	Suited to wet locations subject to flooding.
Frontier reed canarygrass	4	
Champ or Climax timothy	2	
4. Aurora alsike clover	2	For acid soils subject to flooding.
Reed canarygrass	6	

For Hay

1. Beaver or Ladak alfalfa	5	For all but the drier parts of the province.
Carlton bromegrass or Greenleaf pubescent wheatgrass	6	
2. Beaver, Ladak, Roamer or Rambler alfalfa	5	For drier parts of zones 2 and 3.
Summit or Nordan crested wheatgrass	6	
3. Beaver, Ladak, Roamer or Rambler alfalfa	3	For zones 2 and 3 where moisture conditions are variable.
Carlton bromegrass or Greenleaf pubescent wheatgrass	5	
Summit or Nordan crested wheatgrass	3	
4. Beaver or Ladak alfalfa	5	Areas of plentiful moisture.
Champ or Climax timothy	3	
Carlton bromegrass or Greenleaf pubescent wheatgrass	7	
5. Altaswede red clover	5	Grey wooded or black soil areas of plentiful moisture.
Carlton bromegrass	6	
6. Altaswede red clover	5	As mixture No. 5.
Champ or Climax timothy	3	
7. Aurora alsike clover	4	Wet location subject to flooding.
Champ or Climax timothy	3	
8. Aurora alsike clover	4	Areas subject to prolonged flooding.
Frontier reed canarygrass	3	
Champ or Climax timothy	1	
9. Beaver or Ladak alfalfa alone	10	Preferred hay crops in irrigated areas.

Cereal hays. A good deal of cereal hay, sometimes called greenfeed, is fed in Alberta. Cereal crops are easy to grow and furnish a very desirable emergency crop. Early-cut cereal hays are relished by cattle. As the crop ripens, however, the straw becomes coarse, unpalatable and less digestible. Cereal hays are good sources of energy but are usually deficient in protein. University of Alberta experiments showed that oat hay, if supplemented with protein, supported milk production as well as did alfalfa hay, but without this supplementation it had an inferior nutritive value. Cereal hays are especially low in calcium compared to other roughages. The carotene content is usually quite low.

Sometimes cereal hays, when damaged by drought, hail, frost or other conditions, accumulate large quantities of *nitrate*. This material may be converted in the rumen to toxic *nitrite* which can seriously affect the health of the animals and may even result in sudden deaths. Any crops suspected of high nitrate should be analyzed for nitrate, (1) (see page 15).

Silages

High-quality silage is a valuable addition to a feed program. Most crops suitable for hay can be successfully ensiled if proper precautions are taken. A well-ensiled crop is equal or slightly superior in nutritive value to good hay made from the same crop. Silage is usually higher in carotene and keeps its carotene longer than does hay. The protein, energy and mineral content of silage is similar to that of hay from the same crop. Of course, comparisons must be made on an equal dry matter basis as silage contains about 2/3 water.

Curing silages. There are three main essentials in making good silage. The moisture content must be just right, air must be excluded from the body of the silage, and there must be enough fermentable sugars and starches present for the formation of acid. Most poor silages are a result of failing to meet the first two requirements. Silage that is too dry to be densely packed permits air to enter and becomes moldy or heated. The optimum moisture content of materials to be successfully ensiled is about 65%. At a moisture content of less than 60% it is very difficult to pack silage properly, consequently air enters and the silage become moldy or heated. Poorly constructed silos and inadequate packing will also cause these defects even though the moisture content of the silage might be correct. Crops that are ensiled when very young and immature or when too wet tend to become sour, rancid or putrid. These defects are likely to occur when the moisture content of the silage is over 70-75%. This is especially true with legume crops.

It may be necessary to add grain or molasses to silage to increase the supply of fermentable carbohydrates or to lower the moisture content especially when very immature legumes are being ensiled. However, such preservatives add to the cost of silage and should not be used if high quality silage can be made without them. Chemical preservatives have been used successfuly in producing a desirable reaction in silage. However, they do not increase the feed value of silage and, since good silage can be made without them, they are seldom used.

Advantages of silage:

1. Silage is less subject to damage by weather during harvesting than is hay.
2. Crops can be stored as silage in a much smaller space than they can as hay.
3. Silage is usually highly palatable and very succulent.
4. There is less loss of leaf during harvesting.
5. There is less sorting of stems and other less palatable parts of the plant during feeding.
6. Carotene is better preserved.
7. Usually less labor is involved in making silage.
8. Crops which contain unpalatable weeds may be more readily consumed as silage than as hay.
9. The ensiling process destroys many kinds of weed seeds.

Some disadvantages:

1. Upright silos are expensive and there is often considerable waste in trench, pit and bunker silos.
2. Silage has a strong odor and, unless handled carefully in the dairy barn, may taint the milk.

Haylage

Good haylage should be superior in nutritive value to hay or silage made from the same crop. It usually contains 40 to 50% mosture and is less affected by weathering than hay which requires a longer drying period in the field. There is less likelihood of spoilage or nutrient losses in the silo, as compared with silage, since the production of haylage requires an air-tight silo. Because of its lower moisture content, haylage is a better source of dry matter than is silage. The production of haylage requires a high capital investment in air-tight upright silos. Consequently, the long-term economics of such an operation must be carefully compared with that of other methods of conserving roughage before making the initial investment.

Pasture

Pasture produces an almost complete ration for dairy cows. In addition to benefits to the health and nutrition of the herd, pasture is valuable in promoting soil conservation and preserving soil fertility. The pasture season in most areas of Alberta is short, and it is necessary to rely on stored forage for 7 to 8 months of the year. Because of the short pasture season, and since conservation can result in uniformly high quality of roughage and increase the production of available nutrients, some dairymen have reduced their pasture requirements in favor of year-around use of stored forage. Where pasture is to be a part of the dairy enterprise, a good program must be followed to take advantage of the following benefits during the short season that is available.

1. No harvesting equipment or labor is required.
2. Good pasture is extremely palatable and is consumed in much greater quantities than stored forage.
3. Good pasture is higher in carotene and usually higher in protein than is stored forage.
4. Manure is automatically spread on pastures and only a little harrowing is necessary to get the full value from this product.
5. Cattle on pasture get needed exercise. Heat is easier to detect and disease problems can be greatly reduced.

There are a few disadvantages to pasture.

1. Pasture plants must be consumed at all stages of growth and under all summer weather conditions. On the other hand, stored feeds may be cut at a stage of growth in which their nutritive content is at a maximum.
2. Pasture is available for only part of the year.
3. There is always some loss of forage due to trampling by the cattle and to fouling by manure.
4. If pastures are not close to the milking barn, considerable time must be spent taking the cows to pasture and bringing them home.
5. Insects such as flies and mosquitoes are more difficult to control with cows on pasture than with those confined to the buildings.
6. Other crops may yield greater returns.

Legumes should be included in pasture mixtures wherever possible because they increase the protein and calcium content of the forage, give better growth and increase the palatability of the pasture. The recommended level of legume in the pasture mixture and the species of legume to be used will vary with the location of the farm and the management of the herd.

Most perennial grass hay crops that can be cut for hay are suitable for pasture. Brome, timothy, slender wheat grass (western rye), creeping red fescue, red top, crested wheat grass, Kentucky blue grass and reed canary grass may be used in areas suitable for their growth. These grasses are most valuable when grown in mixtures with legumes. See Table 1.

Supplementary pasture crops provide forage before the main dairy pasture can be used in the spring and after it ceases to provide ample forage in the fall. The seeding of temporary pasture crops has proven to be a cheap and satisfactory method of feeding the herd during these periods. In experiments at The University of Alberta, 8 acres of oats seeded in late July provided sufficient pasture for 10 cows for a period of 6 weeks. This pasture replaced five tons of hay and 1,300 lb. of grain which would have had to have been fed under conditions of barn feeding.

Cereal crops, especially oats, are usually used for late fall pasture while fall rye provides the earliest spring crop. Rape pasture can be used for young stock and dry cows but is not suitable for milking cattle.

Concentrates

Because of their high fiber content, roughages cannot be consumed in sufficient quantity to supply the energy needs of high producing cows. Consequently, these cows require a concentrated energy source if they are to produce according to their maximum potential. Such concentrates are known as *energy* or *carbonaceous concentrates.*

To balance a ration that is low in protein, *protein concentrates* or *supplements* are used. These are usually high in energy as well.

ENERGY CONCENTRATES

Cereal Grains

The most commonly fed energy concentrates for dairy cattle are the cereal grains. They supply large amounts of energy and modest amounts of protein to the diet. The protein content of grains varies considerably with the growing conditions of the area and the variety. Grains are very low in calcium but contain fair amounts of phosphorus. With the exception of yellow corn, grains contain no carotene.

Grains should be ground or rolled for most efficient use. They should not, however, be finely ground as this makes them less palatable and more subject to waste. Coarse grinding and rolling are the

most desirable methods of grain preparation. All that is necessary is that the kernel be broken.

Barley is a very suitable grain for dairy cattle feeding. Many times the price of barley is such that it is a more economical source of energy than are oats. Energy should be purchased on the same basis that protein or vitamins are purchased, that is, from the most inexpensive source per lb. of the desired nutrient.

Oats are very widely used in dairy cow rations. They are excellent feed for dairy cows. The fiber content of oats is the highest of our common grains and the energy content the lowest. Consequently, oats can be fed with little danger of overfeeding and digestive upset. They are very palatable. The fat content of oats is fairly high and ground or rolled oats stored for long periods of time, especially in hot weather, may become rancid. Rancid oats are unpalatable but are not toxic.

Wheat is higher in energy and in protein than oats or barley. Experiments at The University of Alberta have shown that as much as 60% of the concentrate allowance can be composed of coarsely ground wheat without any harmful effects on digestion or udder health.

Usually wheat is too expensive for use in dairy rations. But when it is available at competitive prices, there is no reason why it should not be used in concentrate mixtures for dairy cattle.

Rye is similar to wheat in composition and nutritive value but is not palatable for dairy stock. Up to 30% rye may be used in grain mixtures especially if other, more palatable feeds are included. Rye containing ergot must not be used.

Others

Wheat screenings are sometimes available for feeding. Their value depends entirely upon their composition. Some screenings are completely unsuitable for milking rations because of high amounts of chaff and undesirable weed seeds such as stinkweed, while others are almost equal to wheat in feed value. Weight per bushel is a good indication of the feeding value of screenings, but they should also be examined for unpalatable or harmful weed seeds. Screenings should be finely ground to kill weed seeds.

Wheat bran is widely used for feeding dairy cattle. It is not really a protein supplement as it contains little more protein than wheat. It is fairly rich in phosphorus. Bran is considered by dairymen to be useful for special purposes. Bran mashes are often fed to sick animals and to cows before and after calving. Bran is highly palatable and is used to encourage high feed intake or to stimulate appetite in cows that are off feed.

Wheat standard middlings or shorts are similar to bran except that they contain more energy and less fiber.

Brewers grains are sold either wet or dry. Wet brewers grains contain about 75% moisture. Special arrangements have to be made for holding and feeding the wet grains. They may become sour during warm weather when held too long. About 4 lb. of wet grains are equal to 1 lb. of dry grains. Dry brewers grains are not very palatable and are usually mixed with other more palatable concentrates.

Dried beet pulp and dried molasses beet pulp are by-products of the sugar industry. These products are similar to oats in energy content but are considerably lower in protein content. They are very palatable and are sometimes fed to induce high producing cows to consume more energy.

Beet molasses is also a by-product of sugar refining. It contains 20 to 25% moisture and considerable sugar. Molasses provides about as much energy as oats but usually very little digestible protein. It is often used to increase the palatability of poor feeds, especially roughages. In areas close to sugar factories the price of molasses is competitive with other energy sources. However, molasses is quite laxative and a level of over 8 to 10% in the concentrate mixture may cause scours.

Cane molasses is almost identical with beet molasses in nutritive value and composition. It is usually higher in price.

Protein Concentrates

Linseed meal and soybean meal are satisfactory protein supplements for dairy cows. Soybean meal usually contains about 10% more protein than does linseed meal but on an equal protein basis they have about the same feeding value. Both are palatable and easy to mix and feed. They may be used interchangeably according to the relative price of protein from these meals.

Rapeseed meal is becoming more available in Alberta. It is very similar in composition to linseed meal. Although rapeseed meal may not be as palatable to dairy cows as is linseed meal, it is usually readily eaten. This product does not taint milk and does not appear to be harmful for dairy cows. Solvent or pre-pressed solvent meals rather than expeller meals should be purchased.

Meat meal, meat scraps and tankage are all very high in protein, calcium and phosphorus but are not so palatable to cattle as oil seed meals or milling and brewing by-products. However, if meat scraps, etc., are very low in price it may prove economical to use them as protein sources. They should be

mixed with very palatable ingredients and introduced gradually into the rations.

Urea and other non-protein nitrogen compounds can be used as indirect sources of protein because of microbial action in the rumen. Excessive levels of these compounds may reduce feed consumption because of low acceptability, and may be toxic because of the rapid production of ammonia in the rumen. However, they are usually cheaper sources of nitrogen than protein supplements such as soybean meal, and can be used to replace up to one-third of the protein of the concentrate ration of dairy cattle after rumen function has become established. They should be well mixed with other feeds to improve acceptability and to avoid over-consumption by a few animals. It is a good practice to introduce these products into the ration gradually over a period of 2 or 3 weeks.

Mineral Supplements

Rations for dairy cattle frequently require supplementation with calcium and/or phosphorus to provide the necessary balance of these minerals. While mineral supplementation can be done by the "shot-gun" method, it is less expensive and more satisfactory nutritionally to determine the mineral that needs to be added and to supply that mineral in its most simple and inexpensive form. Some commonly used mineral supplements and their approximate composition are given in Table 2. Phosphorus supplements should be purchased on the basis of cost per lb. of phosphorus. The fluorine content of these supplements should not exceed 0.15%. Do not use fertilizer phosphate as a feed supplement.

TABLE 2

APPROXIMATE COMPOSITION OF SOME PRODUCTS COMMONLY USED AS SOURCES OF CALCIUM AND PHOSPHORUS

Product	*Calcium Content*	*Phosphorus Content*
	%	%
Ground limestone	38	0
Feeding bone meal	28	13
Defluorinated phosphate rock	30	18
Calcium phosphate	18.5	20.5
Sodium polyphosphate	0	25

Salt should be available to dairy cattle at all times. Although salt can be fed free choice with little danger of wastage or overfeeding, it is often necessary to make provision for adequate salt consumption by high producing cows. In addition to a free choice offering of salt, it is desirable to add 1 to 1½% salt to the concentrate allowance especially when cattle are confined to stanchions for a large part of the day. When free choice feeding of salt is possible and practical, loose salt is preferable to block salt because the cows are able to satisfy their requirement more easily with loose salt.

Trace mineral supplements other than iodine and perhaps cobalt have not been shown to be necessary for cattle under Alberta conditions. Cobalt and iodine can be supplied quite satisfactorily in cobaltized-iodized salt.

WHAT ARE NUTRIENTS USED FOR?

The nutrients in feeds are used to supply energy for the work done by the vital organs of the body such as the heart, lungs and digestive tract; for the maintenance of body temperature; for the repair of tissues; for the building of new bone, muscle and fat tissues during periods of growth, pregnancy and fattening; and to provide the ingredients required for the secretion of milk.

Maintenance can be compared to overhead costs. Although the nutrients required for maintenance give no actual cash return, the animal must be maintained if it is to produce. The animal requires mostly energy for maintenance while protein and minerals are required only to replace or repair body tissue. The amount of energy needed for maintenance varies with the temperature and with the activity and size of the animal.

Growth and pregnancy require the addition of new tissues. Thus, nutrients must be fed to furnish the materials from which the tissues are built and to supply the energy required to build these tissues. The protein and mineral requirements for growth are much greater than for maintenance. The energy requirement is also increased.

The nutrient requirements for pregnancy are relatively small during the first 5 to 6 months but increase rapidly during the last 3 or 4 months.

Fattening is not really growth but is storage of excess energy as fat. Fattening is usually not desirable in dairy cattle and may even be harmful. Much more energy is required to put on a pound of fat than is needed for a pound of lean, hence feed efficiency for fattening is much lower than that for growth.

Milk production requires a large supply of nutrients. A high producing cow can secrete in a year more than her own weight of nutrients. The cow needs to consume not only the nutrients secreted in the milk but must also be supplied with the energy required to produce and secrete the milk. So great is the nutrient requirement for heavy milk production that only by careful feeding can high producing cows be supplied with sufficient nutrients to meet their needs.

FORMULATING RATIONS

A ration which supplies the nutrients required by an animal at a given time in the proper proportion and amounts is called a complete or balanced ration. In order to formulate a balanced ration, it is necessary to know the nutrient content of the feeds available and the specific nutrient requirements of the animal.

The Nutrient Content of Feeds

The average nutrient content of feeds commonly used in Alberta is given in Table 3. It should be stressed that these figures are only averages of many analyses and that they may not necessarily apply to the individual feeds to be used in a particular circumstance.

Feed Analysis

More accurate information about individual feeds may be obtained through feed analysis. A service is available in Alberta whereby homegrown feeds can be analyzed at a nominal cost. The Agricultural Soil and Feed Testing Laboratory in the O. S. Longman Building, 6906 - 116 St., Edmonton, has been established to supply this service. Very carefully chosen, representative samples of feed should be submitted to the Agricultural Soil and Feed Testing Laboratory in containers that are available from any District Agriculturist. Certain information is requested in the forms that are supplied with the containers. Great care should be exercised in obtaining the sample to see that it is truly representative of that which will be fed.

TABLE 3

AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS[1]

Feedstuff	Total dry matter	Total protein	Digestible protein	T.D.N.	D.E.	Ca	P	Carotene
	%	%	%	%	kcal./lb.	%	%	mg./lb.
Dry Roughages								
Alfalfa hay, early bloom	90	16.6	11.4	52	1050	1.12	0.21	51
Alfalfa hay, mid-bloom	89	15.2	10.8	51	992	1.20	0.20	14
Alfalfa hay, full bloom	88	14.0	10.1	50	960	1.13	0.18	15
Alfalfa hay, late bloom	91	13.9	10.0	46	973	1.21	0.22	11
Barley hay	87	7.7	4.3	50	1002	0.18	0.26	—
Bromegrass hay	90	10.9	5.6	50	1002	0.39	0.25	15
Clover hay, alsike	88	12.9	8.6	50	1002	1.15	0.22	75
Clover hay, red	88	13.1	7.9	52	1042	1.42	0.19	15
Oat hay	90	6.4	3.1	56	1122	0.23	0.21	40
Oat straw	90	4.0	1.3	47	942	0.30	0.09	—
Prairie hay, midwest, late bloom	91	6.9	2.9	51	1022	0.46	0.07	10
Timothy hay, pre-bloom	87	11.8	6.4	54	1082	0.57	0.30	—
Timothy hay, mid-bloom	88	7.5	4.0	54	1082	0.36	0.16	21
Timothy hay, late bloom	87	6.9	3.4	51	1022	0.30	0.18	—
Wheat hay	86	6.5	3.5	45	902	0.10	0.14	44
Wheat straw	90	3.2	0.4	43	862	0.15	0.07	1
Silages								
Alfalfa, not wilted, no preservative	30	5.3	3.6	17	341	0.48	0.16	12
Alfalfa, wilted	36	6.4	4.5	22	441	0.51	0.12	8
Grass legume, no preservative	29	3.4	1.7	13	260	0.23	0.08	30
Grass-legume, molasses added	30	3.4	2.0	15	300	0.28	0.08	31
Oats, no preservative	32	3.1	1.8	19	381	0.12	0.10	17
Concentrates								
Barley, grain	89	11.7	8.8	78	1563	0.08	0.42	—
Beet pulp, dried	91	8.9	4.1	69	1748	0.68	0.10	—
Beet pulp, molasses, dried	92	9.1	6.0	71	1423	0.56	0.08	—
Beet pulp, wet	10	1.4	0.5	8	160	0.09	0.01	—
Brewers dried grains	92	25.9	19.2	60	1203	0.27	0.50	—
Linseed meal, expeller	91	35.3	31.1	74	1483	0.44	0.89	—
Molasses, beet	77	8.4	4.4	61	1223	0.16	0.03	—
Oats, grain	89	11.8	8.8	68	1363	0.10	0.35	—
Rye, grain	89	11.9	9.4	76	1523	0.06	0.34	—
Soybean meal, solvent	89	45.8	41.2	73	1463	0.32	0.67	—
Wheat, hard red spring, grain	90	14.7	11.8	79	1583	0.05	0.47	—
Wheat bran	89	16.0	12.5	62	1243	0.14	1.17	—
Wheat, grain, screenings	89	15.0	10.8	69	1383	0.08	0.39	—
Wheat middlings	90	17.2	12.5	77	1543	0.15	0.91	1.4

[1] Taken with permission from NUTRIENT REQUIREMENTS OF DAIRY CATTLE, Publication 1349, Committee on Animal Nutrition, National Academy of Sciences—National Research Council, Washington, D.C., 1966.

Analysis is especially valuable for roughages as they can vary considerably in protein, calcium and phosphorus content. The only reliable estimate of carotene (vitamin A) content of any roughage is actual analysis.

In Alberta, grains can vary widely in protein content and rations can be balanced more accurately using the actual protein content of feed grains rather than the figures in Table 3.

The T.D.N. and D.E. content of feeds cannot be obtained by feed analysis. Table 3 must be used to obtain T.D.N. and D.E. values for all feeds. Also, neither tables nor analysis can give information about properties of a feed such as acceptability, etc. These must be assessed on the farm by actual observation.

Daily Nutrient Requirements of Dairy Cattle

It is possible to calculate the nutrients required by a dairy cow of a given age, size and production from average values in Table 4.

The requirements for growth in immature animals and for maintenance in mature animals according to body weight are given. To this amount are added the nutrients required for lactation and/or reproduction. The requirements for lactation vary with the amount of milk produced and the butterfat test of the milk.

TABLE 4

DAIRY NUTRIENT REQUIREMENTS OF DAIRY CATTLE[1]
(Based on air-dry feed containing 90 per cent dry matter)

Body wt.	Daily nutrients per animal[2]								
	Total feed	Protein		Energy		Ca	P	Carotene	Vitamin A
		Total	Digestible	T.D.N.	D.E.				
lb.	*lb.*	*lb.*	*lb.*	*lb.*	*Mcal.*	*lb.*	*lb.*	*mg.*	*1,000 IU*
Growth of heifers for herd replacement									
55	0.9	0.20	0.18	1.10	2.2	0.004	0.003	2.5	1.0
110	2.2	0.44	0.40	2.20	4.4	0.009	0.007	5.3	2.1
165	4.4	0.75	0.53	3.30	6.6	0.018	0.013	7.9	3.2
220	6.2	0.95	0.62	4.18	8.4	0.021	0.018	10.6	4.2
440	11.4	1.14	0.84	6.93	13.9	0.029	0.026	21.2	8.5
550	13.6	1.39	0.88	7.81	15.6	0.031	0.029	26.4	10.6
770	17.6	1.48	0.91	9.90	19.8	0.035	0.033	37.0	14.8
990	20.2	1.60	0.96	10.34	20.7	0.035	0.033	47.7	19.1
1210	21.6	1.68	1.01	10.78	21.6	0.035	0.033	58.0	23.2
Maintenance of mature cows									
770	11.4	0.82	0.50	6.16	12.3	0.022	0.022	37	14.8
990	13.6	0.99	0.59	7.04	14.1	0.026	0.026	48	19.2
1210	17.2	1.17	0.73	8.36	16.7	0.033	0.033	58	23.2
1430	18.9	1.34	0.80	9.24	18.5	0.037	0.037	69	27.6
1650	21.6	1.52	0.91	10.23	20.5	0.044	0.044	80	32.0
Reproduction (add to maintence during last 2 to 3 months of gestation)									
880	8.8	0.88	0.53	5.28	10.6	0.022	0.018	22	8.8
1210	11.0	1.01	0.60	6.60	13.2	0.029	0.024	30	12.0
1540	13.2	1.21	0.73	7.92	15.8	0.035	0.031	38	15.2
Lactation—Nutrients per lb. of milk (add to requirements for growth or maintenance)[3]									
For cows producing more than 77 lb. of milk daily.									
3% fat		0.078	0.050	0.36	0.72	0.003	0.002		
4% fat		0.088	0.056	0.42	0.84	0.003	0.002		
5% fat		0.098	0.062	0.48	0.96	0.003	0.002		
6% fat		0.108	0.070	0.54	1.08	0.003	0.002		
For cows producing 44 to 77 lb. of milk daily.									
3% fat		0.070	0.045	0.32	0.64	0.002	0.002		
4% fat		0.078	0.051	0.37	0.74	0.002	0.002		
5% fat		0.086	0.056	0.42	0.84	0.002	0.002		
6% fat		0.094	0.060	0.47	0.94	0.002	0.002		
For cows producing less than 44 lb. of milk daily.									
3% fat		0.062	0.040	0.28	0.56	0.002	0.002		
4% fat		0.070	0.046	0.33	0.66	0.002	0.002		
5% fat		0.078	0.050	0.38	0.76	0.002	0.002		
6% fat		0.086	0.056	0.43	0.86	0.002	0.002		

1 Taken with permission from NUTRIENT REQUIREMENTS OF DAIRY CATTLE, publication 1349, Committee on Animal Nutrition, National Academy of Sciences—National Research Council, Washington, D.C., 1966.
2 The original data are in kilograms and grams. These have been converted to pounds using 2.2 lb. per kilogram.
3 When calculating the intake for lactating heifers that are still growing, it is recommended that the figure for growth rather than maintenance be used.

The requirements for growing heifers may be taken directly from the table. Dry cows are usually in the last 3 months of pregnancy so that the allowance for reproduction should be added to that for maintenance. Some examples of how Table 4 can be used are given below.

Example 1

Calculate the nutrient requirements for a 2year-old heifer weighing approximately 800 lb. and producing 30 lb. of 4% milk daily.

	Total Protein lb.	*T.D.N. (energy)* lb.	*D.E. (energy)* Mcal.	*Ca* lb.	*P* lb.	*Vitamin A* I.U.
Growth	1.48	9.90	19.8	0.035	0.033	14,800
Lactation	2.10	9.90	19.8	0.060	0.060	—
Total	3.58	19.80	39.6	0.095	0.093	14,800

Example 2

Calculate the nutrient requirements for a mature cow weighing approximately 1,200 lb. and producing 40 lb. of 3% milk daily during the last 3 months of pregnancy.

Maintenance	1.17	8.36	16.7	0.033	0.033	23,200
Lactation	2.48	11.20	22.4	0.080	0.080	—
Reproduction	1.01	6.60	13.2	0.029	0.024	12,000
Total	4.66	26.16	52.3	0.142	0.137	35,200

Example 3

Calculate the nutrient requirements for a 1,400 lb. cow producing 60 lb. of 4% milk daily.

Maintenance	1.34	9.24	18.5	0.037	0.037	27,600
Lactation	4.68	22.20	44.4	0.120	0.120	—
Total	6.02	31.44	62.9	0.157	0.157	27,600

Steps in Formulating Rations

1. Use the feeds that you have available or that you can easily and economically obtain and those with which you are familiar.
2. Begin with the roughage as the basis of the ration. Consider the roughage that you have available and decide how much of this will be readily consumed. Usually 2 to 2½ lb. of hay per 100 lb. of body weight is a realistic figure for average quality hay. Three pounds of silage are equivalent to 1 pound of hay.
3. Add to the hay enough grain (of the kind available) to supply the energy (T.D.N. or D.E.) required.
4. Make additions as necessary of protein or mineral supplements. If a large amount of protein supplement is needed, it should replace some of the grain instead of being added to the grain.
5. Where feed analysis is available, use analysis figures for protein, calcium, phosphorus and carotene. Use figures from Table 3 for T.D.N. or D.E.
6. All cows should have free access to iodized or cobaltized-iodized salt and to fresh, clean water.

Example Formulations

The nutrient contribution of a feed is calculated by multiplying the weight of feed by the per cent composition for each nutrient. Thus 21 lb. of oat hay contains:

$$\frac{21 \times 6.4 \text{ (Table 3)}}{100} = 1.34 \text{ lb. protein.}$$

$$\frac{21 \times 56 \text{ (Table 3)}}{100} = 11.76 \text{ lb. T.D.N.}$$

$$21 \times 1122 \text{ (Table 3)} = 23{,}562 \text{ kcal or } \frac{23{,}562}{1{,}000} = 23.56 \text{ Mcal.}$$

$$\frac{21 \times 0.23 \text{ (Table 3)}}{100} = 0.048 \text{ lb. Ca, etc.}$$

In the following ration formulations for the requirements in example 3 the calculations are carried to 2 or 3 decimals so that it is possible to follow the mathematics used. In practice, these figures would be rounded off to 1 decimal for protein, T.D.N. and D.E., 2 decimals for Ca and P, and to 10 mg. for carotene. Neither feed composition tables nor nutrient requirement tables are as accurate as the figures in these calculations suggest.

Circumstance (A)

Oat hay and oat silage are available. Oat grain is fed. Linseed meal is available.

Feed $1.5 \times 14 = 21$ lb. oat hay
$3 \times 14 = 42$ lb. oat silage

This represents an equivalent of 2½ lb. of dry roughage per 100 lb. body weight.

This supplies	*Protein*	*T.D.N. (energy)*	*Ca*	*P*	*Carotene*
	lb.	*lb.*	*lb.*	*lb.*	*mg.*
Hay	1.34	11.76	0.048	0.044	840
Silage	1.30	7.98	0.050	0.042	714
Total	2.64	19.74	0.098	0.086	1554
Requirements	6.02	31.44	0.157	0.157	69
Less	2.64	19.74	0.098	0.086	1554
We still need	3.38	11.70	0.059	0.071	—
Add 11 lb. oats					
This supplies	1.30	7.48	0.011	0.038	—
We still need	2.08	4.22	0.048	0.033	—
Add 6 lb. linseed meal					
This supplies	2.12	4.44	0.026	0.053	—
We still need	—	—	0.022	—	—
Add 0.1 lb. ground limestone (Table 2)					
This supplies	—	—	0.038	—	—

This ration meets the requirements for the nutrients considered.

Circumstance (B)

Timothy hay (mid-bloom) is available. Barley is fed. Soybean meal can be purchased. Since only timothy hay is fed, it is expected that less roughage will be consumed i.e. 2 lb. per 100 lb. body weight.
Feed 2 × 14 = 28 lb. hay

This supplies	*Protein*	*T.D.N. (energy)*	*Ca*	*P*	*Carotene*
	lb.	*lb.*	*lb.*	*lb.*	*mg.*
Hay	2.10	15.12	0.101	0.045	588
Requirements	6.02	31.44	0.157	0.157	69
Less	2.10	15.12	0.101	0.045	588
We still need	3.92	16.32	0.056	0.112	—
Add 17 lb. barley					
This supplies	1.99	13.26	0.014	0.071	—
We still need	1.93	3.06	0.042	0.041	—
Add 4.5 lb. soybean meal					
This supplies	2.06	3.28	0.014	0.030	—
We still need	—	—	0.028	0.011	—
Add 0.1 lb. defluorinated phosphate rock					
This supplies	—	—	0.030	0.018	—

This ration meets the requirements for the nutrients considered. Because of the lowered roughage intake more concentrates were required.

Circumstance (C)

Alfalfa hay (mid-bloom) is available. Barley grain is fed. Bran can be purchased.
Feed 2½ × 14 = 35 lb. hay

This supplies	*Protein*	*T.D.N. (energy)*	*Ca*	*P*	*Carotene*
	lb.	*lb.*	*lb.*	*lb.*	*mg.*
Hay	5.32	17.85	0.420	0.070	490
Requirements	6.02	31.44	0.157	0.157	69
Less	5.32	17.85	0.420	0.070	490
We still need	0.70	13.59	—	0.087	—
Add 18 lb. barley					
This supplies	2.11	14.04	0.014	0.076	—
We still need	—	—	—	0.011	—
Add 0.06 lb. dicalcium phosphate (Usually just offer free-choice)					
This supplies	—	—	0.011	0.012	—

This ration meets the requirements and supplies an excess of protein and calcium. Both these nutrients had to be added to rations A and B. Bran is not needed.

What is a Suitable Ration?

Not all rations which supply the required amounts of nutrients are suitable for dairy cattle, nor is the ration which supplies these nutrients at the least cost necessarily the most economical. It is necessary to consider the suitability of the ration from the standpoint of acceptability to the animal, possible injury to the animal or to the milk, ease of feeding and many other factors which vary from year to year and from farm to farm. Fortunately, rations can usually be balanced using feeds with which the producer is already familiar.

Thumb Rules

There are two popular thumb rules for feeding dairy cattle.

1. 2 to 2½ lb. roughage for each 100 lb. body weight plus 1 lb. of concentrate for each 3 to 4 lb. of milk daily depending on the test. High-testing cows should receive a higher concentrate allowance.

2. 2 to 2½ lb. roughage for each 100 lb. body weight plus 1 lb. concentrate per day for each lb. of butterfat produced per week.

However, thumb rules can be used only as guides in formulating rations. They are accurate only for cows producing 30 to 40 lb. milk per day, and indicate too much feed for low producers and too little for high producers. The quality of roughage is also important. If either very good or very poor quality hay is used, thumb rules should not be relied upon.

Feeding and Management of the Dairy Herd

Dairying cannot be profitable unless the cattle are fed adequately and efficiently and are handled so as to avoid discomfort, injury and illness. The combination of the many factors involved in these objectives is called management. Many management procedures cannot be adequately described nor explained, but certain principles apply in all circumstances and on all farms. Each producer should attempt to apply good management principles to his own set of conditions.

RAISING DAIRY CALVES

The most satisfactory method of obtaining replacements for a dairy herd is to raise them. Except for operations on very high-priced land or under high-cost conditions, it is almost always less costly to raise replacements than to buy them. Even if this were not so, it would still be sound practice to avoid purchasing replacement animals. Heifers that are raised at home have several advantages over those purchased.

1. Disease control. A producer who has used a good system of disease control knows the health and disease history of each heifer. If he does not have a disease on his farm, his own cattle cannot introduce it. Purchased animals are the principal source of new disease on any farm and should be examined thoroughly by a veterinarian before purchase. Even then they may carry defects or organisms which cannot be detected by even the closest examination. In addition, many animals are bought at public sales premises where they can easily pick up several new infections which did not evist on their original farms. Most disease is bought—and paid for.

2. Production level. Most herds can be improved more rapidly and inexpensively by the use of good sires through artificial insemination and by within-herd selection than by purchases. It is posible to have accurate information of the production of the dams of replacements and to save the best heifers for the milking line. Animals are frequently purchased with no knowledge of the production history of the animal or its dam. Very few farmers sell their top producing stock so that usually the less desirable ones are offered for sale.

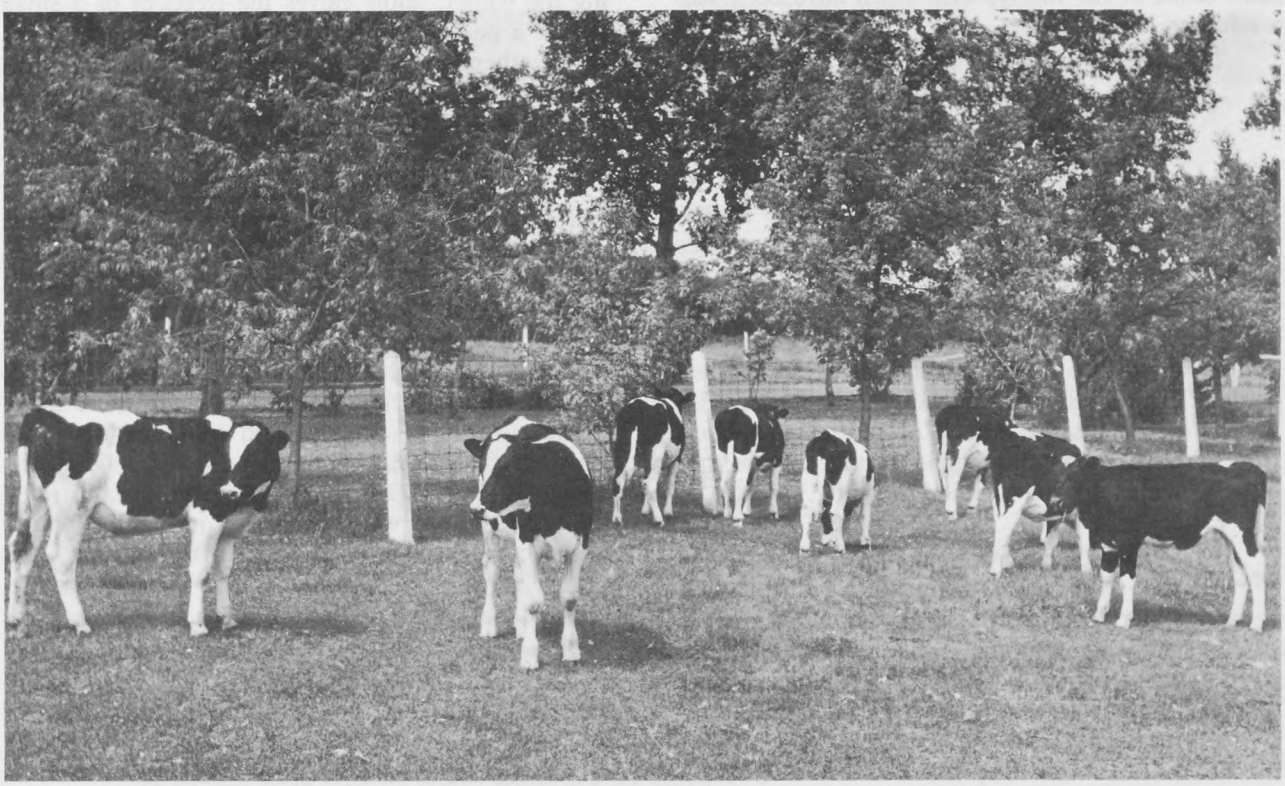


Figure 1—Carefully raised, well-bred calves become economical, high-producing cows in the milking herd.

Calves should be raised carefully so that they will provide a reliable source of high-quality replacements.

Care of the Calf

At birth, check the calf to see that it is breathing properly. Disinfect the navel with tincture of iodine. If the calf has not suckled within a few hours, give assistance to make sure that it gets colostrum.

Colostrum must be received by the calf for at least the first 36 hours of life. Without colostrum, the problems of raising a healthy calf are multiplied considerably. Although colostrum contains a high level of many nutrients such as vitamin A and protein, it has a value far greater than its nutrient content. Colostrum contains antibodies which are absorbed during the first few hours of life and give the calf temporary resistance to the many disease germs present in even the cleanest environment. Without this immunity, the calf is subject to scours, digestive upset, pneumonia and any number of diseases which prevent healthy growth and are often fatal.

It is usual practice to see that the calf gets colostrum for the first 3 days of life. This is good, but the first day is the most important.

Subsequent feeding of the calf can vary greatly depending on the conditions on the individual farm. Several methods of feeding can give excellent results. Some of the the systems which have been successful are listed below.

1. Limited whole milk followed by skimmilk. Calves are fed whole milk for 3 to 5 weeks and then changed, either abruptly or gradually, to skimmilk. Calf starter or a grain mixture is offered as soon as it will be eaten and is gradually increased as the skimmilk is decreased. This system gives excellent growth but is often expensive.
2. Limited whole milk plus a calf starter. Whole milk is fed in decreasing amounts for 4 to 6 weeks and the calves are weaned directly to a high-quality calf starter. Experiments at The University of Alberta have shown that good results can be obtained by this method weaning as early as 3 weeks.
3. Milk replacer. Commercial milk replacers are available which, when mixed with water, are approximately equal in composition to skimmilk. Milk replacer can very conveniently be used as early as 3 - 5 days of age after the calf has finished colostrum feeding. Calves are weaned onto a dry starter when they are about 4 weeks old, or they can be fed milk replacer until they have reached 130 to 135 lb. in weight. They should not be weaned until they have started to consume the dry starter. This method is economical for fluid-milk shippers especially when producing at or below their quota. Those who ship churning cream will usually find that skimmilk is cheaper to feed than is milk replacer.

Keep fresh water and good hay available at all times. Calves should be encouraged to eat dry matter as early as possible. The sooner a calf is eating a high-roughage diet, the better.

Suggested feeding schedules are given in Table 5.

From 4 months to a year of age the calf should be fed so as to continue good, steady growth. Avoid excess flesh and too rapid growth. Encourage the calf to eat as much roughage as possible and feed grain in only sufficient amounts to keep the calf in thrifty flesh. Use highest quality hay for calves of this age.

Calves from the age of 6 months to a year will thrive on good pasture if it is well managed and supplies adequate forage at all times. If the pasture is dry or scanty, grain must be given. Calves are very susceptible to parasite infestation, and pastures should be rotated to keep this problem to a minimum.

Exercise is essential for calves of all ages. During the winter, allow calves the freedom of a small pen in a part of the barn that is well lighted. When the weather is not too severe they may be kept outdoors during the day. In the summer, calves should have ample space on good grass with shade and shelter available.

Yearling heifers are not difficult to feed. They will make normal growth on good quality roughage with little or no grain. Yearling heifers are often kept too fat. If the farmer is to make a mistake in feeding his heifers, it would be best to under-feed, rather than over-feed them. Recent experimental work has shown that heifers that are over-fed produce less milk during later life and are more likely to have breeding troubles and other health problems than are normal or under-fed heifers. Experiments at The University of Alberta demonstrated that heifers that were underfed during the winter were not permanently set back in their growth and produced as well during the first lactation as did well-fed heifers.

Pregnant heifers are managed in the same way as yearling heifers until about 2-3 months before calving. At this time begin feeding a few pounds of grain so that they are gaining in flesh at the time of calving. However, they must not be allowed to get too fat before calving. Desirable weights at

calving are given on page 30. If heifers are considerably heavier than these weights, they are perhaps carrying too much fat.

CARE OF COW AT CALVING TIME

The cow must be handled so that she has her calf with a minimum of injury, discomfort or infection and can return to her normal health and appetite as quickly as possible.

A few days before she is due to calve, the cow should be confined to a clean, well-bedded stall and receive all the good hay she will eat plus her concentrate allowance. Keep fresh, warm water readily available. First-calf heifers require especially gentle handling so that they may become accustomed to their surroundings.

Cows may be allowed to care for their calves as soon as they are dropped. Cleanliness at this time is important for the health of the calf and as a means of protecting the herd from disease. If an abortion occurs, the dead calf and the afterbirth should be carefully removed and burned and the box stall disinfected.

A mature cow in good condition will usually expel her calf without any assistance. However, some assistance may be necessary for young heifers and for cows that are weak, overly fat or that fail to develop normally in their pelvic area. When the calf is being presented in an abnormal position, it is often possible to manipulate it into normal position to facilitate expulsion.

It is important to treat cows with kindness during parturition. Cows handled quietly and gently will allow the attendant to give any necessary assistance during parturition and can be quickly induced to let down their milk.

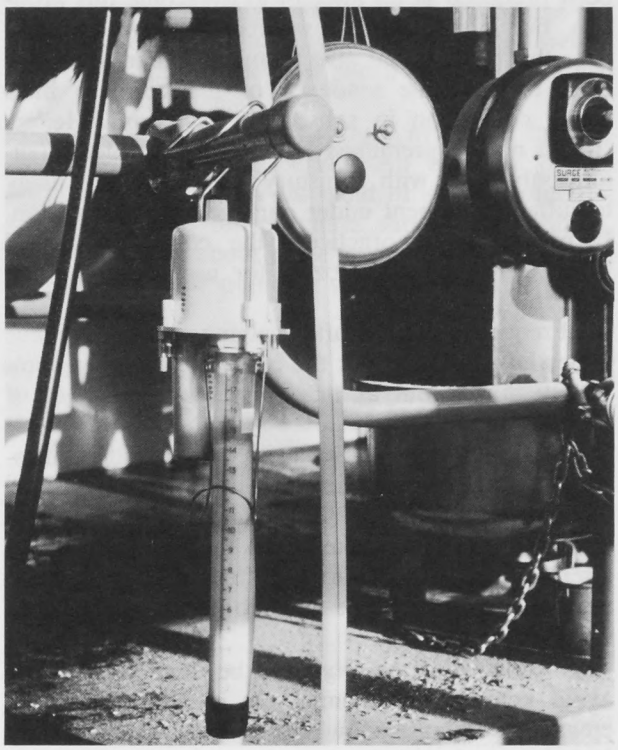


Figure 2—Weighing and recording milk is not a difficult nor a time-consuming task, and the information gained is invaluable as a guide to profitable dairy production.

Udder congestion or inflammation is a very serious problem especially in high-producing cows. Milking of cows before calving (premilking) has

TABLE 5
FEEDING SCHEDULES FOR CALVES

	Colostrum	*Whole Milk*	*Skim Milk*	*Milk Replacer*	*Calf Starter*	*Grain Mixture*
(1) Fluid milk producer with some surplus or manufacturing milk producer	1st 3 days	250 lb. total 1st 4-6 weeks in decreasing amounts per day	.....	.....	10 days to 2 months free choice	2 months to 1 year—3-4 lb. per day
(2) Fluid milk producer with little surplus	1st 3 days	150 lb. total 1st 3-4 weeks in decreasing amounts per day	.....	.....	10 days to 2 months free choice	same as (1)
(3) or	1st 3 days	.....	.....	As directed by manufacturers 1st 4-6 weeks	same as (1)	same as (1)
(4) Churning cream shipper with excess skim milk	1st 3 days	.....	10-12 lb. per day to 4 mo.	.....	.....	From 6 weeks to 4 mo. full feed. 4 mo. to 1 year 3-4 lb./day

Note:—(a) Calf starter should be given after 10 days of age while calves are receiving milk or milk replacer. Calves may be weaned when they are readily consuming the starter.
(b) Calves should receive excellent hay or good, parasite-free pasture plus iodized salt and fresh, clean water.

been practiced in an attempt to overcome this problem, but it has been shown recently that not only does this practice not give permanent relief, but may even increase the tendency of the cows to have udder congestion in subsequent lactations. Heifers should not be premilked if it can be avoided. Usually only cows with a history of mastitis are likely to suffer permanent udder damage from congestion. If premilking is practiced, the colostrum should be saved, preferably frozen, for use when the calf is born.

Frequent milkings after calving will help relieve udder inflammation but the cow should not be completely milked out as this increases the danger of milk fever.

If the udder is still congested it should be massaged, given heat applications or otherwise treated to remove the inflammation. Some dairymen believe that when the calf is taken from the cow a few hours after birth, it is easier to train the cow for the normal milking procedure and to teach the calf to drink from a pail.

Feeding after calving must be done carefully to avoid ketosis (acetonemia). It is desirable to increase concentrate allowance to the level necessary for the cow's production as rapidly as possible without causing indigestion or putting her off feed.

A suggested schedule is to feed 10 lb. of concentrate to all cows the day after calving. Increase this by 1 lb. per day until the cow is receiving concentrates according to her production. An allowance of 24 lb. per day in most cases is the maximum which needs to be fed.

FEEDING THE MILKING HERD ON PASTURE

In Alberta, we have a pasture season of only 4 to 5 months. During this time, the farmer should take full advantage of the low cost and excellent nutritive value of pasture. Pastures should be managed to give maximum value.

The value of pasture in the ration of dairy cows depends on the following:

1. The crops used. The proportion of legumes to non-legumes, the species of legumes and grasses used and their adaptability to the area influence the possible maximum value of a pasture.
2. The stage of maturity. The value of a pasture decreases rapidly as the plants mature. At the time of blooming this loss becomes accelerated so that a few days may make an enormous difference in pasture quality. Legumes are more seriously affected at this time than are grasses. Any management system that permits a long-term supply of young, rapidly growing forage will increase the value of the crop.
3. The density of growth. A mature cow can eat well over 100 lb. of fresh grass a day. The more dense the stand of grass, the more the cow will be able to consume and the more valuable the pasture will be.
4. Moisture supply. Not only does drought reduce the stand of pasture but, in addition, the nutritive value of grass decreases rapidly as the plants dry. Although it is usually impossible to control climatic conditions, it is necessary to know how they affect pasture growth so that proper supplementation can be made.
5. The grazing environment. The most valuable pastures have available shade and shelter. They are relatively free from mosquitoes and other insect pests. There is an abundant and clean water supply and salt is available to the cow. Disturbing influences such as dogs and frequent visitors are absent.

Some Grazing Systems That Have Been Used To Improve Pasture Quality

1. *Rotational grazing.* Several fields are fenced permanently and are grazed in sequence so that the cattle can frequently be moved off old pasture and onto new. This provides for control of excess growth by clipping and protects against over-grazing.
2. *Strip grazing.* This is a form of rotational grazing but is arranged with temporary fences so that only one day's pasture allowance is made available each day. In this way the fouling and trampling of pasture that may occur under other systems are reduced.
3. *Zero grazing or soiling.* In this system the cattle are confined to corral and clipped pasture is hauled to them. The cost involved and the suitability of this system in a given locality should be thoroughly investigated before such a system is undertaken.

Grain Feeding on Pasture

High-producing cows cannot consume enough pasture to meet their energy requirements. In order to maintain high production under pasture conditions some concentrate must be fed. In most cases, protein supplement is not necessary for cows on pasture so that only farm grains need be fed.

The best rate of grain feeding depends on the condition of the pasture, the production of the cow and the relationship between the cost of grain and the price of milk. Excellent, well-managed pastures can support production up to 40 or 45 lb. of milk per day, but our usual good pastures supply energy

for only 25 or 30 lb. per day with average pastures supporting less that this.

Cows should be fed enough grain to maintain their usual production. This amount will vary throughout the pasture season as the pasture changes in value. Whenever pastures begin to decline, the concentrate allowance should be increased to maintain production. An approximate guide to grain feeding for cows on pasture is given in Table 6.

2. Approximately how much of the forage the cow will voluntarily eat. Time spent weighing hay to see how much cows will eat can be valuable.
3. The amounts of forage available for the whole feeding period. An estimate of the amount of hay on hand or of how much is available for purchase should be accurate. It takes about three tons of hay to carry a dairy cow over the winter feeding period.

TABLE 6
GRAIN FEEDING TABLE FOR COWS ON PASTURE[1]

Quality of pasture			*Total pounds of grain mixture or concentrates to feed*						
Excellent	*Good*	*Fair*	*Percentage of fat in milk*						
Milk produced daily			*3.0%*	*3.5%*	*4.0%*	*4.5%*	*5.0%*	*5.5%*	*6.0%*
lb.	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*
22	13	..	...	...	...	...	...	...	1.2
24	15	..	...	...	...	...	1.2	2.0	2.3
26	17	..	...	...	...	1.9	2.2	3.1	3.5
28	19	10	...	...	1.6	2.8	3.2	4.2	4.6
30	21	12	1.5	2.0	2.4	3.8	4.2	5.3	5.7
32	23	14	2.3	2.8	3.3	4.7	5.2	6.3	6.8
34	25	16	3.0	3.6	4.2	5.6	6.2	7.4	8.0
36	27	18	3.7	4.4	5.0	6.5	7.2	8.4	9.1
38	29	20	4.5	5.2	5.9	7.5	8.2	9.5	10.2
40	31	22	5.2	6.0	6.8	8.4	9.2	10.5	11.3
42	33	24	6.0	6.8	7.6	9.3	10.2	11.6	12.5
44	35	26	6.7	7.6	8.5	10.3	11.2	12.7	13.6
46	37	28	7.4	8.4	9.3	11.2	12.2	13.7	14.7
48	39	30	8.2	9.2	10.2	12.1	13.2	14.8	15.8
50	41	32	8.9	10.0	11.1	13.1	14.2	15.8	17.0
52	43	34	9.6	10.8	11.9	14.0	15.1	16.9	18.1
54	45	36	10.4	11.6	12.8	14.9	16.1	18.0	19.2
56	47	38	11.1	12.4	13.7	15.9	17.1	19.0	20.3
58	49	40	11.8	13.2	14.5	16.8	18.1	20.1	21.5
60	51	42	12.6	14.0	15.4	17.7	19.1	21.1	22.6
62	53	44	13.3	14.8	16.3	18.7	20.1	22.2	23.7
64	55	46	14.1	15.6	17.1	19.6	21.1	23.3	Regard-
66	57	48	14.8	16.4	18.0	20.5	22.1		less of the
68	59	50	15.5	17.2	18.9	21.4			amount of grain
70	61	52	16.3	18.0	19.7	22.4			theoretically required by
72	63	54	17.0	18.8	20.6	23.3			a cow she should not be
74	65	56	17.7	19.6	21.4				fed more than she can safely handle

1 Taken by permission of The Morrison Publishing company, Clinton, Iowa, from the 22nd Edition, third printing, 1959 of FEEDS AND FEEDING by F. B. Morrison and Associates.

FEEDING THE HERD IN DRYLOT

In Alberta, dairy cattle are fed in drylot for 7 or 8 months of the year. This means that much of the success of the dairy enterprise depends on efficient, economical feeding practices during this time. Each feeding program is governed to a large extent by the amount, kind and quality of the roughage available. It is desirable to have an ample supply of high-quality roughage on hand. If this is not possible, a feeding program must be designed to make up for the deficiencies of the roughage.

The following information is necessary.

1. The composition of the forage. This is best obtained by an actual analysis (page 15). Some information can be obtained from feed composition tables if the forage is not badly damaged or otherwise not typical.
4. The composition of the grain. Actual analysis gives the most accurate information.
5. The amount of grain on hand or available. High-producing cows need over a ton of grain per year.
6. The price and suitability of locally available supplements.
7. The allowances necessary for heifers and calves. A safe allowance for heifers is 2 tons of hay and ½ ton of grain and for calves, 1 ton of hay and ½ ton of grain for a year in addition to pasture.

Balance Rations Often

This should be done as was described on page 17 every time there is a major change in the amount or quality of roughage fed. No one can afford to

use a ration balanced for his neighbor or for himself last year.

Feeding According to Production

The daily feed requirements must be met to obtain efficient and profitable milk production; overfeeding low producers and underfeeding high producers is not economical in most situations. The simplest way of insuring proper feeding is to formulate a ration for the herd average. A satisfactory rule in planning rations is to feed roughage according to body weight and grain according to production. A dairy cow will consume 2½ lb. of an excellent quality hay for every hundred pounds of body weight, but less of a poor quality roughage. The rate of grain feeding will depend on the amount of roughage consumed (See Tables 6 and 7).

TABLE 6

GRAIN FEEDING GUIDE (lb.) WITH EXCELLENT *FORAGE

Lbs. milk per day	*Milk Fat 3.5%*	*4.0%*	*5.0%*
20	0	0	0
25	0	0	3
30	0	1	6
35	3	4	9
40	5	6	11
45	8	9	14
50	10	11	17
55	13	15	22
60	16	18	26
65	19	22	31
70	24	26	35
75	29	31	
80	33	36	
85	37	40	
90 and above	Feed grain to maximum appetite		

* Forage calculated at 60 per cent TDN with an intake of 2½ pounds per 100 pounds of body weight.

Taken from Alberta Farm Guide p. 140.

TABLE 7

GRAIN FEEDING GUIDE (lb.) WITH GOOD *FORAGE

Lbs. milk per day	*Milk Fat 3.5%*	*4.0%*	*5.0%*
20	3	5	7
25	6	7	10
30	8	9	12
35	11	12	15
40	13	14	18
45	16	18	22
50	19	21	26
55	23	25	30
60	27	29	34
65	31	33	
70	35	37	
75	39		
80			
85 and above	Feed grain to maximum appetite		

* Forage calculated at 50 per cent TDN with an intake of 2 pounds per 100 pounds of body weight.

Taken from Alberta Farm Guide p. 141.

Production and Breeding Records are Important

It is impossible to feed according to production if the production of each cow is not recorded. This is only one of the many benefits of good record keeping.

Testing a cow does not increase her production, but the information gained enables the farmer to make improvements in feeding, selection, culling and management that will raise his herd average rapidly and considerably.

In addition to production it is important to record the breeding history of the animal. Accurate breeding records are often as valuable as production records.

Information concerning official production testing plans can be obtained from the Dairy Herd Improvement Division of the Dairy Branch of the Alberta Department of Agriculture, Edmonton.

Feed Records are Also Important

Just as the measurement of output of a dairy enterprise is important, so also is measurement of the input. Concentrates should be weighed and a specified amount given to each cow. Feeding by volume has many drawbacks, especially when feeds of different bushel weights are used. Proper ration formulation, which is the basis of economical, efficient feeding, is dependent on accurate feed weights and records.

The Dry Period

Cows produce more if given a 6-8 week dry period before calving. This rest period is necessary to permit the regeneration of the mammary tissue and, in many cases, to build up body nutrient reserves. Cows should be dried off by abruptly stopping milking in order that the udder can build up the concentration of substances that enhances the combating of bacterial infection. Gradual drying off only prolongs the process.

For cows producing over 25 pounds per day, the limiting of grain and water starting two days before drying off may help to reduce swelling and discomfort. Dipping the end of the teat in a 5% tincture of iodine solution serves to reduce the bacterial concentration at the teat canal opening and will also remind the milker that the cow is being dried off and should not be milked. The dry period should be used for treating cows with histories of mastitis.

Dry cows should be fed all the good quality forage they will eat. Good quality pasture is sufficient. Grain feeding should be commenced about two weeks before calving with ½ lb. of regular herd mix per 100 lb. body wt. and increased to near full feed by calving time. Some U.S. authorities recommend 15-18 lb. per day. After calving the amount

of grain fed should be increased until the point of maximum milk yield is reached and this level of feeding held through the first 60-90 days of lactation and then reduced to the lowest level which does not reduce milk yield. The dry period should be used to accustom the cow to high levels of grain feeding and to avoid loss of time in bringing her to full feed after calving.

Milking Practices

The main objectives of developing a good system of milking are to:

1. use labor as efficiently as possible,
2. avoid injury or irritation that might lead to infection,
3. reduce stress on the cows so that milk production is not reduced by the milking process, and
4. produce clean, high-quality milk.

Milk Let-down is Important

The events that are regularly connected with milking such as massage of the udder, the clank of buckets or the presence of the milker, stimulate the release of the hormone oxytocin from the pituitary gland of the cow. This hormone in the blood stream causes the let-down of milk. It usually takes about 1 minute from the time of stimulus to milk let-down.

In order to take full advantge of this let-down cycle, the milker can control it to some extent. The most effective stimulus is washing the udder in warm water 1 minute before putting the machine on the cow. Of course, this operation has the added advantage of cleaning the udder. Anything that detracts from the let-down cycle such as pain, fright, discomfort or anything unexpected should be avoided. Gentleness and regularity during milking give best results.

Cows that are treated so as to take advantage of good milk let-down milk more quickly, more completely and are less likely to contract mastitis from milking machine irritation than are cows less carefully milked. In addition, the proper stimulation of milk let-down has been shown to increase milk production.

The Requirements for Good Machine Milking

1. Good equipment. All milking equipment must be kept in excellent repair. Keep the vacuum according to the manufacturer's specifications and check it often. Pulsators should be clean and working properly. Keep teat-cup liners and other parts in excellent condition. Service equipment often and replace anything questionable. It is false economy to "make-do" with milking equipment.
2. Good operation. Each cow is an individual and must be treated according to her special

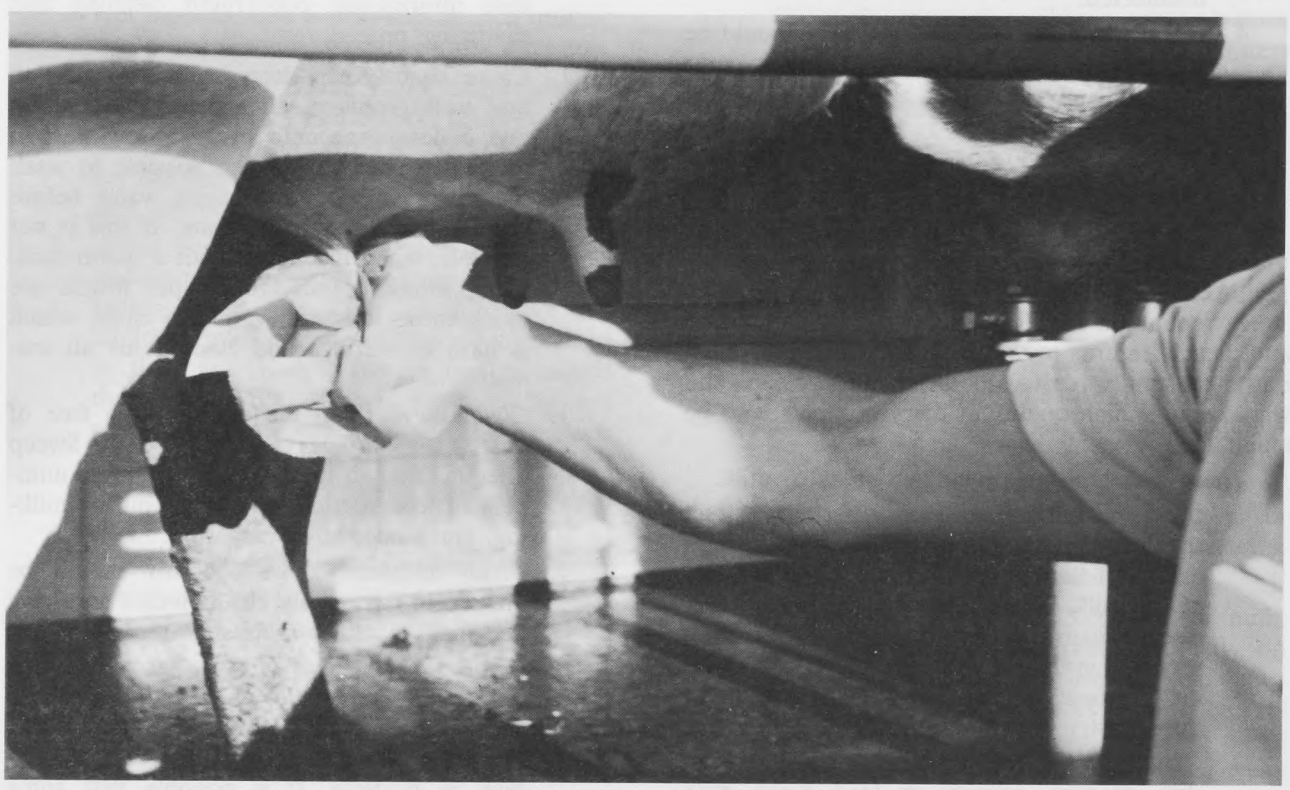


Figure 3—Washing the udder aids in promoting milk let-down.

needs. Stimulate let-down before the machine is put on. Milk the cow as quickly as possible. The machine must *not* be left on any quarter after milk has stopped flowing. Give injured, diseased or abnormal quarters special attention. Handle the cows regularly, gently and competently.

3. Good sanitation. Mastitis is an infectious disease and its spread can be controlled to some extent by sanitary procedures. In addition, milk can become contaminated during the process so that its quality is lowered. For healthy cows and clean milk, sanitation is essential. Test all quarters with a strip-cup and milk infected or suspicious cows last. Sanitize the teat cups between each cow. Teat dipping, immediately after each cow is milked, is an essential practice in the control of mastitis. The teats should be dipped in a solution containing approximately 10,000 ppm of iodine to obtain proper disinfection. At the present time only three products that meet the requirements for teat-dipping are available in Alberta. Because of the importance of this aspect of the milking routine, dairymen should obtain professional advice from the Department of Agriculture to ensure they are using a product with the correct specifications. Between milkings, all equipment should be properly cleaned and disinfected.
4. Good labor use. The milking area should be so arranged that the milker can work comfortably and efficiently. Establish a routine to reduce unnecessary walking, stooping, bending and carrying. Each man should be expected to operate a minimum of 2 and a maximum of 3 machines.

PRODUCING HIGH-QUALITY MILK

A reputation for high quality increases markets and, hence, returns to the producer. Each individual must constantly strive to keep milk clean and wholesome if high quality in dairy products is to be maintained.

There are three major contaminants of milk.

1. *Bacteria.* Large numbers of bacteria affect the keeping quality of milk. Some species cause off-flavors or alter the physical state of the milk. There is always the danger that disease causing organisms may find their way into milk. All of these defects can cause serious losses to the individual farmer or to the industry in general.
2. *Visible dirt.* Foreign particles such as hair, dirt, manure, insects or feed make milk highly undesirable to any consumer. These materials can be filtered out of the milk, but their presence in the raw milk indicates careless milking procedure. Although visible contaminants do not usually add large numbers of bacteria, such dirt usually indicates poor techniques which allow high bacterial counts to arise.
3. *Adulterants.* Chemicals are constantly being used for medication, cleaning, insect and weed control, etc. Many of these materials somehow find their way into milk. The presence of some of these such as antibiotics or insecticides is a very serious matter. These materials must be kept out of milk. Other adulterants cause bad odors and flavors to make milk quite unattractive. Small amounts of rinse water are sometimes present in the milk. This should be kept to a minimum by careful practice.

Keep Milk Clean

1. *Properly sanitized utensils.* The majority of the bacterial contamination of milk comes from non-sterile utensils. A careful program in which every surface that the milk touches is adequately sanitized should be developed and religiously followed. The neglect of cleaning procedures even for a short period of time can be disastrous. Consult all available information concerning cleaning and sanitizing procedures.
2. *Clean cows.* Keep dairy cows well bedded and well groomed. Clip their hindquarters and udders, especially during the winter. In milking parlors, it is often possible to wash the udder with warm running water before milking—this should be done. If this is not possible, wash the udder with a warm sanitizing solution. Individual paper towels are much more satisfactory than a cloth, which is hard to sterilize and is used for all animals.
3. *Clean barn.* Keep the milking area free of dust, feed particles and bad odors. Sweep after milking so there will not be large numbers of feed particles in the air during milking. Have adequate ventilation.
4. *Clean operator.* The operator should be dressed in reasonably clean clothes and have personal cleanliness habits.
5. *Healthy cows.* Cows must be tested for brucellosis and tuberculosis. In addition, watch the herd constantly for signs of mastitis. Mastitis milk is of poor quality and may be high in bacteria. It is possible that some

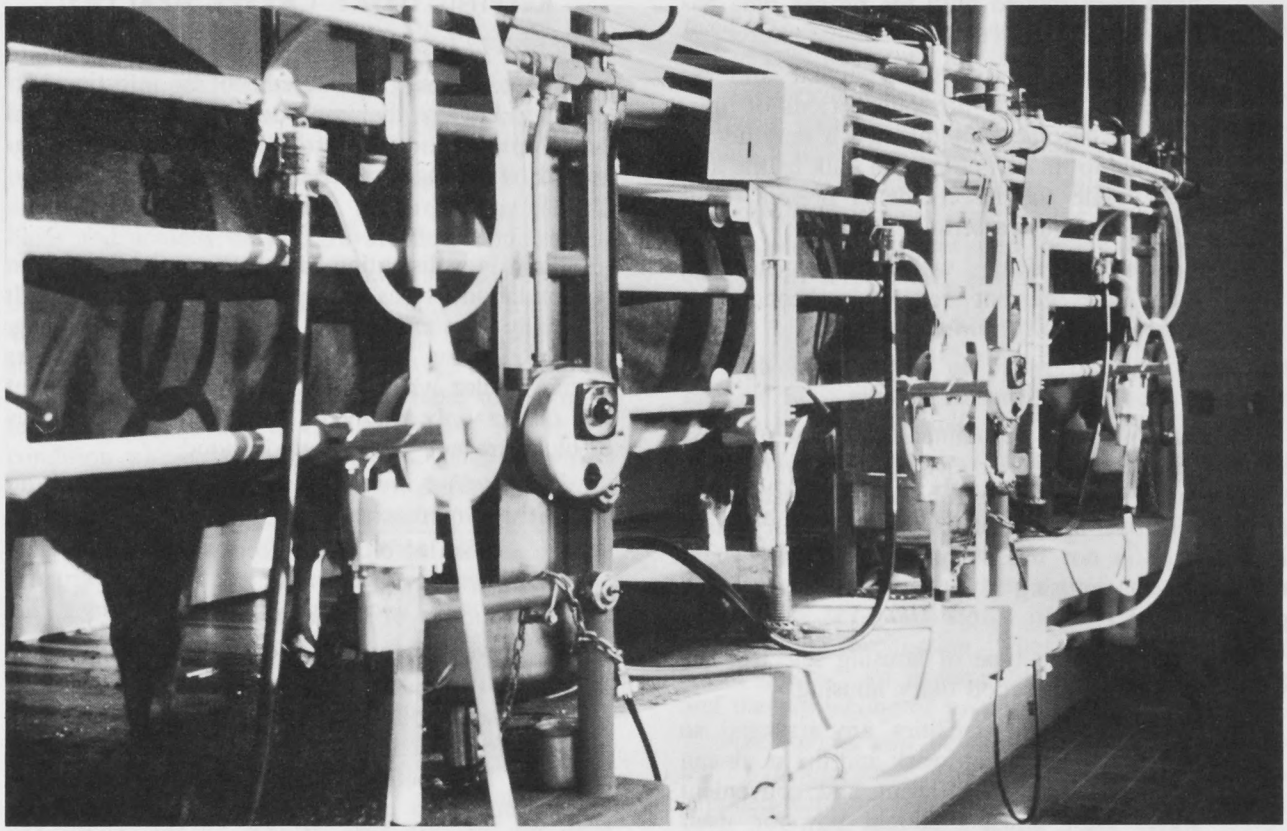


Figure 4—Milking parlors are becoming popular. They provide comfortable, convenient, efficient milking facilities.

of the organisms that cause mastitis can infect humans. Use a strip-cup at each milking and practice active mastitis control measures.

6. *Control insects.* There is no longer any excuse for large numbers of flies in dairy premises. Start an active fly control program for the comfort of the cows and the milkers and for the sake of quality-milk production.
7. *Avoid feed odors.* Weeds such as stinkweed and pasture crops such as rape, if fed before milking, will give milk an off-flavor. In addition, milk easily picks up odors present in the barn. Keep pastures free of weeds that flavor milk. If it is necessary to use pasture or feeds which cause off-flavor, use them several hours before milking and then withdaw them. Feed silage after milking.
8. *Water in milk.* It is not enough merely to avoid deliberately adding water to milk. Wash and rinse equipment carefully in order to keep the water out of milk.
9. *Sediment test and plate count.* Follow these tests as closely as your production figures. Any drop in milk quality should be investigated immediately and the trouble eliminated.
10. *Antibiotics are very serious contaminants.* The seriousness of antibiotic contamination of milk cannot be overemphasized. Farmers who have antibiotics in their milk are subject to severe penalties. The manufacturer's instructions concerning withholding of milk after antibiotic treatment must be followed strictly. Careless or too frequent use of antibiotics, especially without consulting a veterinarian, is not only dangerous and costly but very likely to be ineffective in controlling disease.
11. *Treat insecticides with respect.* Modern insecticides are very effective but also very poisonous. Use according to the manufacturer's instructions. Danger can arise from their careless use and storage on the farm. Not only are stock occasionally lost from insecticide poisoning, but cases of human poisoning are not unknown.

    Insecticides *must* be kept out of milk. Use only allowed preparations directly on cows. If insecticides are used on buildings, manure piles or other places, it must be recognized that if cattle have access to these places they may accidentally consume some of the chemical. Do not use any crops that

have been treated until the proper time has elapsed as specified by the manufacturer.

Insecticides are stored in fat and retained in the body for long periods of time. If cattle become contaminated it may not be possible to market either the milk or the animals while the insecticide is present. This could constitute a serious loss.

Use insecticides with extreme care and know the current regulations concerning them.

HOUSING

It is impossible to recommend one type of housing that is best for Alberta. Conditions vary from farm to farm; consult experts before undertaking the large, expensive investment of building dairy facilities. There is not much chance to change one's mind after the housing is built, so it must be well planned.

Regardless of the type of housing selected, the following characterize good dairy housing.

1. *Convenient.* The facilities are arranged so that the operator can work and the stock can be handled in an efficient and convenient way. New housing should pay for itself largely by the amount of labor it saves per unit of milk produced.
2. *Easily cleaned* and easily kept clean.
3. *Comfortable,* providing comfort for the animals and a pleasant environment for the operator.
4. *Safe,* free from sharp corners and places where injury can occur, with adequate facilities for restraining cows for handling and treatment and constructed to minimize fire risks and other dangers.
5. *Well ventilated.* The major ventilating problem is the disposal of moisture. In poorly ventilated barns there is enough air for cows to breathe but moisture accumulates to the point where the animals cannot be comfortable regardless of the temperature. This high humidity is accompanied by bad odors and dirty walls and floors. A barn must be well enough ventilated to prevent condensation even in the coldest weather.
6. *Attractive.* An attractive barn and yards add to the value of a farmstead and to the reputation of the farm and herd. A well-proportioned barn of good appearance which is painted to harmonize with the other buildings need not cost any more than a poorly planned, ugly building.

KEEPING DAIRY CATTLE HEALTHY

Management Diseases

These diseases are caused, not by infectious organisms, but by the improper function of normal body processes. They are best controlled or prevented by management systems.

Bloat

Bloat is a distention of the rumen caused by an accumulation of gas entrapped in a stable foam. It is usually seen after cattle have been grazing young, rapidly growing legume crops. Some bloat occurs in the feedlot when high-grain rations are fed but this occurs only rarely in dairy cattle. The causes of bloat are not yet fully understood.

Preventative measures are generally based on one of three approaches:

1. dilution of bloatable feed with non-bloatable forage,
2. reduction of fermentation rate, and
3. prevention of foam formation with fats and oils.

The oldest dilution method and still the best long-range protection is the use of grass-dominant pastures. This method is quite effective if palatable grasses make up about 50% of the stand. Strip-grazing has been employed with varying success, but for the most part is impractical because intake must be severely limited for good protection. Certain animals will bloat on as little as 12 pounds of green legume, an amount quite insufficient to maintain even the poorest producer.

A second means of prevention is the use of antibiotics. These agents prevent bloat by inhibiting the initial rapid release of fermentation gases and in so doing permit the animal more time for expelling these gases. Effectiveness declines markedly after about three weeks because the bacteria have a tendency to adapt to most antibiotics. Feeding several different antibiotics in succession or in combination has been successful. Bloat prevention, by means of penicillin administered at the rate of 200-500 mg. per head every third day, is quite effective when succulent, rapidly growing pastures are being grazed for short periods (2-3 weeks).

Use of anti-foaming agents is a third method of bloat prevention. These compounds reduce foam stability by altering ingesta surface tension. Turpentine is one of these agents and has been used for many years as a drench. Its use is not recommended, however, because of serious side effects.

The most satisfactory surface-active agents in effectiveness, palatability, availability, cost and lack of side effects are animal tallows and vegetable oils. Pasture bloat is very effectively controlled by ad-

ministration of 3-4 fluid ounces of tallow or vegetable oil per head per feeding period. Its effectiveness disappears after 3 to 4 hours, necessitating frequent administration. Spraying pasture or feeding oil in a grain mix before consumption of bloatable herbage is an effective means of prevention. Fats and oils are not effective in preventing feedlot bloat and actually may aggravate this condition.

Treatment. Bloating animals should be kept under constant surveillance after removal from feed. Walking the animal or elevating the front feet slightly may provide relief. However, if bloat persists, 8 to 12 fluid ounces of vegetable oil administered with a stomach tube will normally relieve the condition within 10 to 15 minutes. This method is not effective with feedlot bloat nor during the terminal stages of legume bloat. A knife or trocarcannula is the only recourse during terminal stages. A veterinarian should be called immediately following emergency puncture of the rumen to properly care for the wound.

Milk Fever

Milk fever is a disease of high producing dairy cows, usually between the ages of 4 and 9 years, and occurs between 12 and 72 hours after calving. As the disease occurs shortly after calving, the first symptoms of nervousness and excitability are often not noticed. The animal soon shows difficulty in standing and finally goes down.

The symptoms of the disease are caused by a low level of calcium in the blood. However, a lack of calcium in the diet or in the body is not the primary cause of milk fever. The disease seems to be associated with an impairment of the cows ability to use the calcium stored in her body.

Prevention. The feeding of high levels of calcium during the dry period is not recommended. In fact, such a practice may actually aggravate milk fever. To reduce the incidence of milk fever, in the latter part of the dry period the cow should be fed a ration that is low in calcium, but which contains an adequate level of phosphorus.

Some success has been obtained by feeding very high levels of vitamin D for 3 to 4 days prior to calving. This means that accurate breeding records must be kept because the vitamin should not be fed at these levels for over 5 days and is ineffective unless fed for at least 3 days. Use this plan in close consultation with a veterinarian.

If a cow gets milk fever once, she is likely to be affected every subsequent time she calves. Do not milk out such cows completely for the first 60-72 hours after calving. If milk fever is a general herd problem is may be necessary to treat all cows in this way. Incomplete milking should not be practiced with cows who have a history of mastitis and is not usually necessary for first-calf heifers.

Treatment. Uncomplicated milk fever is very effectively treated by injections of a calcium gluconate solution by a veterinarian. Use the practice of inflating the udder with air only in the greatest emergency because of the danger of injury or infection; keep equipment used for inflation extremely clean and, if possible, sterile.

Acetonemia (Ketosis)

This is a disease of high-producing cows that may or may not be associated with calving. It is sometimes confused with, or is a complication of, milk fever. The so-called digestive form, not associated with calving, is characterized by loss of appetite and weight and a marked reduction in milk production.

The disease occurs when a cow must draw too heavily on her body stores of energy for calving and/or milk production. There is a lowering of blood glucose, an accumulation of fat in the liver and the production of so-called ketone bodies.

Acetonemia can be almost completely controlled by management. The object is to keep the cow supplied with enough energy so that she does not have to utilize her own body stores of fat extensively.

1. Keep the cows full of good quality roughage.
2. Avoid using silage shortly after calving, especially poor-quality silage.
3. Avoid anything that might put the cows off feed such as abrupt changes in feed, feeding poor-quality feed or unbalanced rations.
4. Keep the cows comfortable and avoid excitement or pain.
5. Bring the cows onto a full feed of grain as rapidly as can be safely done, see page 22 and 24.
6. Avoid having cows excessively fat at calving.

Medicated feeds are available but they are an expensive and unsatisfactory substitute for good management. Molasses, sugar and similar additives are usually ineffective.

Treatment. There are certain drenches and injections that are very effective for treatment. Use these in consultation with a veterinarian.

Infectious Diseases

These diseases are caused by the growth of infectious organisms such as viruses, bacteria, protozoa or molds in the host animal. The most commonly encountered infectious diseases in dairy cattle are mastitis and some infections of the reproductive

tract in mature animals, while scours and pneumonia are of major significance in calves.

The spread of infectious diseases and, in some cases, resistance to these diseases or the severity of the diseases can be greatly affected by the feeding, management and sanitation practices in a dairy herd. The most effective programs on any individual farm for disease prevention and control are best developed with the aid of a competent veterinarian. Veterinary service should not be restricted to emergency calls, but should be on a consultation basis. This does not necessarily mean increased veterinary costs.

The Veterinary Laboratory, Alberta Department of Agriculture, Edmonton is operated as a public service diagnostic laboratory serving livestock owners directly or indirectly through their veterinarians. Correct diagnosis is a prerequisite to treatment.

REPRODUCTION IN DAIRY CATTLE

When to Breed Heifers

The appearance of puberty is influenced by breed and level of nutrition. Body size is more important in determining sexual maturity than is age.

Heifers may be bred when their rate of growth will take them to a safe size at the end of gestation. A safe calving size for Holsteins is about 1,070 pounds before calving or 950 pounds after; for Guernseys 780 pounds before or 700 pounds after; and for Jerseys 760 before or 680 pounds after. Size at first breeding has little effect on final body size if the animal is fed to permit normal growth and lactation.

When to Breed During Heat

Animals bred too early in the heat period often fail to conceive. Ovulation in the cow normally occurs 12 hours after heat ends, and if insemination is too early, the sperm may either be dead or the ovum not yet ready for fertilization when they meet. For best results, insemination should take place during the last half of the heat period and no later than 6 hours after heat has ended.

When to Rebreed After Calving

A 12-month calving interval appears to be about optimum and nearly as good as a 15-month interval from the standpoint of life-time milk production. An interval of less than 12 months may reduce milk production.

Research has shown that rebreeding should not take place for at least 60 and preferably 80 to 90 days after calving if maximum conception rate and health are to be maintained. Breeding sooner than this increases breeding difficulties because the reproductive organs have not had sufficient time to return to normal from the previous calving.

Breeding Problems

Even in the best managed herds some cows fail to reproduce because of infection, anatomical abnormalities or hormone imbalances. These defects should be diagnosed and treated on an individual basis by a competent veterinarian.

If reproductive failure is a herd problem, a crtical review of the feeding and management of the herd is necessary especially regarding the following five items.

1. *Disease control.* An adequate brucellosis control program is essential. It is also desirable to consider methods of preventing or controlling other venereal diseases such as vibriosis. Effective sanitation and isolation methods are necessary to control other reproductive diseases.
2. *Proper time of breeding.* Poor detection of heat and breeding at the wrong time in the heat period can result in poor fertility.
3. *Rebreeding after calving.* Breeding too soon after calving is a major cause of breeding problems.
4. *Nutrition.* Rations should be checked to see that they supply ample nutrients for high-producing cows. Deficiencies of energy, protein, carotene, iodine or phosphorus may cause reproductive failures.
5. *Exercise.* Daily turnout has been shown to improve conception.

The services of a veterinarian are necessary in assessing the causes of reproductive problems and in recommending changes.

Artificial Insemination

Artificial breeding is a powerful means of increasing herd production because it enables the average breeder to secure the services of bulls much superior to those he can afford to buy. Artificial insemination is also used to prevent or control certain diseases.

Breeding cows artificially requires special equipment, and the collection, preparation and insemination of the semen requires technical and sanitary practices. Consequently, highly trained personnel are used in the many operations required.

Dairy Cattle Production in Alberta

DAIRY CATTLE BREEDING

By

W. COMBS

Breeds

Lactation is a specialized form of production for which distinctly specialized milking breeds have evolved over the past 200 years. Extremes have arisen such as the Holstein with a high milk yield but low milk fat percentage and the Jersey with relatively low milk yield and high milk fat percentage. Other breeds are generally intermediate in these traits except that Guernsey milk is highest among domestic breeds in non-fat solids content. To what extent breed differentiation has been due to basic genetic differences in the original foundation stocks or to subsequent selection by breed developers is not clear. It may be as reasonable to believe that in the early stages of breed development man adapted his usage of these breeds to their characteristics as to believe that he effectively selected his animals toward preconceived goals. The relatively large number of sires required when the breeds were largely under natural breeding and lack of precise measures of productivity would tend to support the view that differentiation among breeds occurred very early in their establishment. Average milk and fat yields for a recent year achieved by artificially-sired daughters of the major dairy breeds in Canada are given in Table 8.

In Canada the Holstein is by far the most popular breed for dairy purposes with the Jersey and Ayrshire about equal, followed by the Guernsey (Table 9).

TABLE 9

REGISTRATIONS OF DAIRY CATTLE IN CANADA

	1962		1968	
Breed	*No.*	*%*	*No.*	*%*
Ayrshire	11,230	9.2	10,475	8.8
Brown Swiss	340	0.3	510	0.4
Canadian	1,012	0.8	893	0.7
Guernsey	6,415	5.2	4,681	3.9
Holstein	90,500	74.0	92,800	78.4
Jersey	12,201	10.0	8,668	7.3
Red Poll	628	0.5	257	0.2
TOTAL	122,326		118,284	

Though increasing in registrations, there are, surprisingly, very few Brown Swiss bred in Canada despite their popularity in parts of the United States and their relatively high milk production. Brown Swiss bulls have found their way into some of the bull studs in Canada recently and their use in A.I. will no doubt increase their popularity. The Brown Swiss is finding increased usage in beef cattle cross-breeding.

TABLE 8

R.O.P.—AVERAGE PERFORMANCE BY BREED—1967-68

		Average Age at Freshening			*Production to 305 days*					
	Breed	*Yrs.*	*Days*	*Days in Milk*	*Milk*	*Fat*	*% Fat*	*B. C. Milk*	*A. Fat*	*No. Records*
Alberta	Ayrshire	5	14	317	9,841	379	3.85	121	114	338
Canada	Ayrshire	5	61	319	9,340	378	4.05	116	114	11,980
Alberta	Guernsey	4	176	307	8,260	402	4.87	111	108	105
Canada	Guernsey	4	343	327	8,676	421	4.85	114	111	6,337
Alberta	Holstein Friesian	4	289	334	12,375	443	3.60	115	112	2,126
Canada	Holstein Friesian	4	322	338	12,334	462	3.75	114	117	79,472
Alberta	Jersey	4	131	320	7,319	381	5.21	107	103	222
Canada	Jersey	4	314	319	7,736	411	5.31	111	110	10,200
*B.C.	Holstein Friesian	4	302	341	13,986	524	3.75	130	133	2,578

Prepared by A. A. Hughes, Animal Industry Division, Alberta Department of Agriculture.

The Canadian breed traces to 17th century importations from France. It is similar to the Jersey in size, though darker in color, and probably of similar genetic background. The Canadian breed is found almost exclusively in Quebec.

Holstein, Brown Swiss and even Ayrshire steers can distinguish themselves for beef production. They gain as rapidly, and frequently as efficiently as recognized beef breeds, and produce leaner carcasses but generally do not fatten sufficiently at acceptable market weights to meet present standards for the Canadian Choice grade. Crosses from these dairy breeds have proven to be superior to the standard beef breeds in milking ability, growth rates and carcass meatiness. Holstein × Hereford crossbred cows have weaned substantially heavier calves in Alberta R.O.P. beef tests than Hereford herdmates.

Dairy Steers for Beef Production

The advantage in growth rate of fast growing dairy breeds over standard British beef breeds has been reflected in greater lean and bone growth in comparisons between British Friesian and Hereford steers. Total fat production *at standard ages* was equal. However, because the onset of fattening occurs *at earlier weights,* steers of the British beef breeds are fatter than steers of the larger dairy breeds when killed at equal weights.

Comparisons among Holstein, Jersey, Brown Swiss beef breed crosses and the beef breeds have been reported by Dr. R. T. Berg at The University of Alberta. Complete details may be gotten from 1963, 1967, 1969 and subsequent University of Alberta Feeders' Day Reports.

In U.S. tests, Jersey steer carcasses have proven to be superior to beef breeds in tenderness and palatability as judged by consumer tests. Holstein beef was as palatable as Angus and Hereford. Both Jersey and Holstein beef had lower average cooking losses than that of the beef breeds tested.

There is an increasing demand for dairy crossbred heifers, especially Brown Swiss, as foundation stock for commercial beef breeding herds. Both the Holstein and the Brown Swiss have been incorporated with the Hereford into the Hays Convertor, a new beef breed developed by Senator Harry Hays of Calgary, and into a beef breed development project at George Ross' Lost River Ranch near Manyberries.

Contemplated changes in Canadian beef carcass grading standards may further enhance opportunities for dairymen to capitalize on the beef qualities of their cattle.

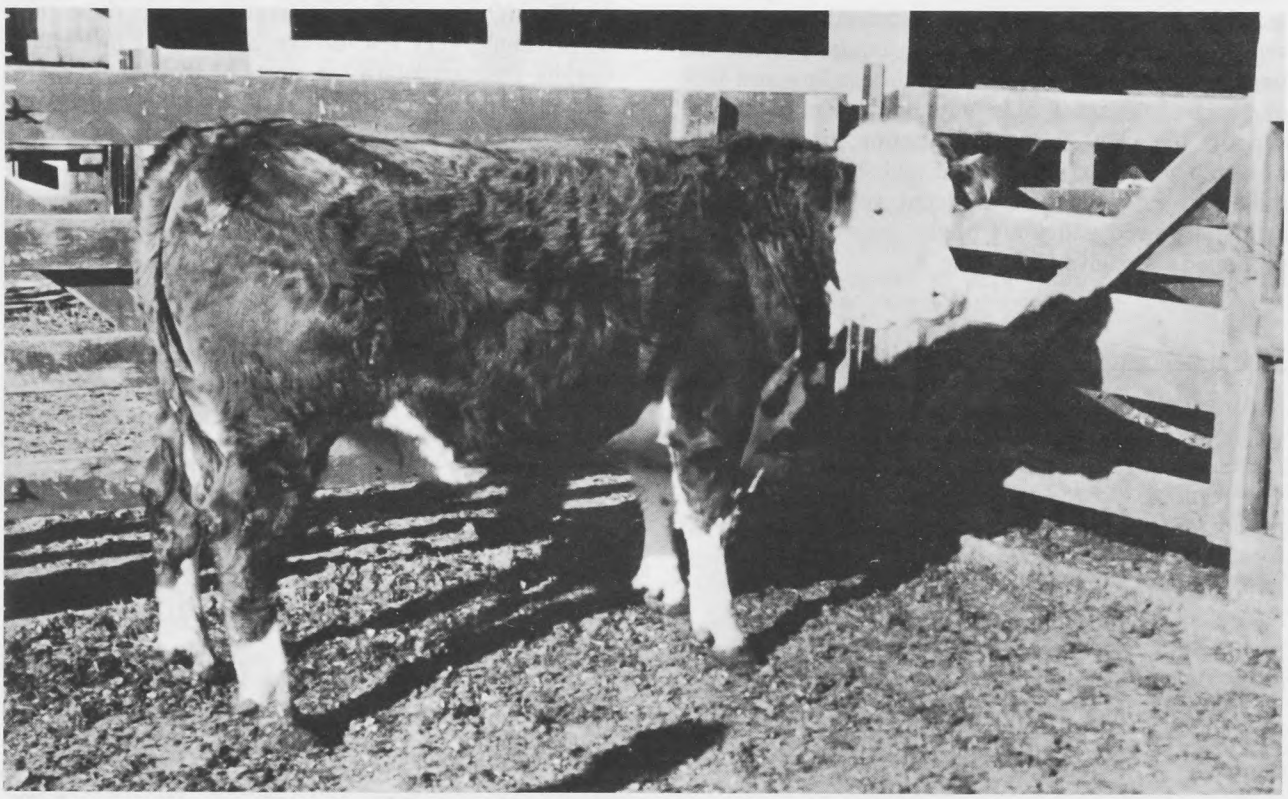


Figure 5—1170 lb. yearling steer from Hereford sire and Guernsey-Holstein 3 yr. old dam. Birth wt. 100 lb.; 180 day weaning wt. 688 lb. (without creep feed); average daily gain (153 day test) 3.24 lb.; hot carcass wt. 675 lb.; ribeye area 10.2 sq. in.; av. fat cover 0.9 in.; kidney fat 3.8%; carcass grade "Canada Good". Bred by The University of Alberta.

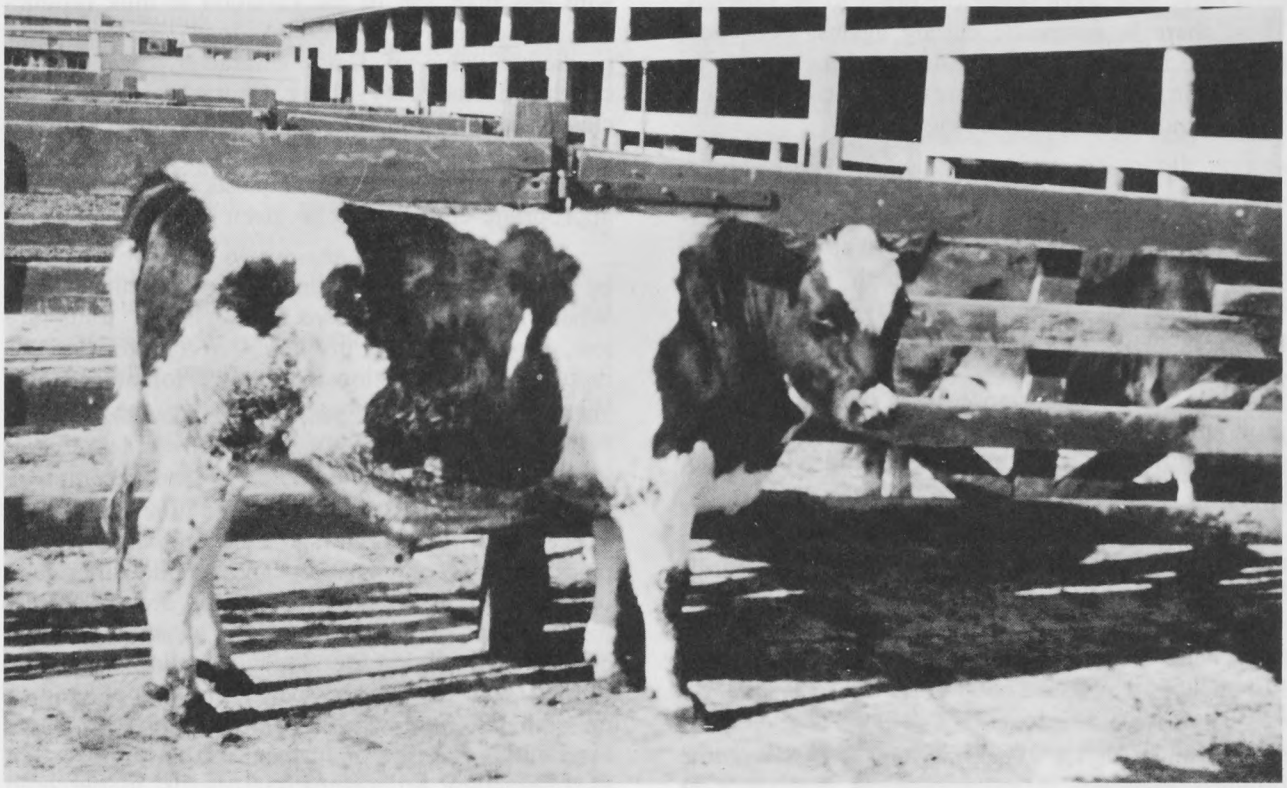


Figure 6—1105 lb. yearling Ayrshire steer. Average daily gain (153 day test) 3.01 lb.; hot carcass wt. 641 lb.; ribeye area 8.8 sq. in.; av. fat cover 0.6 in.; kidney fat 5.7%; carcass grade "Canada Good". Bred by S. R. Fulks, Waskatenau.

Principles of Dairy Cattle Improvement

Improvement in productive efficiency through breeding can result only from selection and culling or by controlling the mating system. Selection should be based only on economically important traits. The inclusion of extraneous traits reduces the selective pressure which can be exerted on those of prime economic importance.

Approximate heritabilities for the most important traits in dairy cattle are given in Table 10 Heritability refers to that portion of the observed variation in a trait which is due to genetic factors that will respond to selection. Heritability excludes variation due to environmental influences or to gene interaction such as observed in heterosis. When heritability is high, good progress can be expected from selection and culling. When it is low, relatively less progress will be achieved.

TABLE 10

HERITABILITIES OF DAIRY CATTLE CHARACTERISTICS

	Heritability—%
Total milk yield	30
Fat percentage	50
Total fat yield	30
Reproductive performance	0-10
Longevity	0-10
Type	20-30

Milk Yield, Fat % and Fat Yield

Total milk production is the most important economic factor in dairy production. Fat production has decreased in importance in recent years with increased emphasis on the non-fat components (protein-lactose-minerals) in milk. Because there is a positive relationship between fat % and non-fat solids, breeds and individuals within breeds with higher % fat usually have a higher content of non-fat solids. There is a slightly negative association between fat % and total milk yield. As milk yield goes up, percent fat tends to go down and vice versa. However, total milk and total fat production in a lactation tend to be highly correlated, as one goes up, so does the other.

Breeders generally emphasize total milk production in selection but should keep a wary eye that fat and non-fat solids content remain sufficiently high for their particular market.

Reproductive Performance, Survival and Longevity

Unfortunately, the heritability for what might be termed fitness characteristics is low and the opportunity to emphasize them in a selection program is limited. Since genetic contribution of an individual to a herd is in proportion to the number of descendants contributing to the herd, animals that do not reproduce regularly or that leave the

herd early will leave fewer offspring to be selected. Thus, there is automatic culling against poor performance in these traits. Substantial benefits can be derived in fitness traits, however, by crossbreeding (see section on crossbreeding).

Type

Type in dairy cattle has been given considerable attention as a result of its emphasis in the show ring and as a result of high values which buyers place on cows with high type ratings. The great publicity given to All-Canadian and All-American contests has placed further emphasis on type. Its actual importance in a dairy production program has been greatly over-rated. Type and production are only slightly related and type cannot be considered indicative of production.

The most prominent sire of All-Canadian winners in 1969 including the All-Canadian Get-of-Sire has consistently sired daughters averaging 10-11% less milk than their contemporaries. Despite his well established record for lowering milk production, he remains highly popular as attested by his having nearly 2000 tested daughters.

Actually, any emphasis in type will lower the progress expected in production as compared to selection for production alone. An analysis of the relationship of type and production by U.S. Department of Agriculture scientists showed that only a few dairy farmers were dependent upon as much as 25% of their income from variations in type. However, for 95% of the dairymen, variations in milk production were 20 times as important to their income as were variations in type. It was further found that allowing even one-fourth of the total selection pressure to be placed on type as compared to three-fourths on production would reduce progress in improving milk production some 5 to 7% below that to be realized if selection were on production alone. If type is given equal selective importance with production, each type classification grade is given equal value to 2,500 lb. of milk in Holsteins and 2,100 lb. in Jerseys. Expected progress in improving milk production will be reduced approximately 30%.

The correlations between production and most items on the dairy cattle type score card are near zero and in some cases are negative. An analysis of official classification records on Holsteins in Michigan made between 1963 and 1966 revealed that variation in Dairy Character ratings was predictive of only 13% of the variation in milk production in the lactation subsequent to first classification. Variations in General Appearance, Body Capacity, Mammary System, Fore Udder, Rear Udder, Feet and Legs, and Rump ratings were each associated with less than 1% of the variation in milk production and collectively added less than 1% to the low predictive value of Dairy Character. The authors concluded that only Dairy Character merited inclusion in type classification but that the definition of what the rating for Dairy Character included was so nebulous as to raise questions regarding the appropriate emphasis to be given Dairy Character.

It is inefficient to attempt to improve one trait by selecting for another under most circumstances. When genetic correlations between the traits are low, progress on the primary trait (production) is reduced if any selection is practised for other traits. When genetic correlations are negative, the improvement of production may be completely frustrated by selecting for conformation.

The argument that purebred breeders must select for type even though the commercial dairymen need not is fallacious. The genetic differences between purebred and grade herds are practically nil after four or more generations of grading up because the remaining foundation breeding is reduced by half with each successive generation of grading up with purebred sires. Therefore, purebred herds are limiting the rate of further genetic improvement in production for commercial herds if purebred breeders are diluting their selection for production by selecting for type.

Type selection should be included only to eliminate animals with major disqualifying characteristics which will definitely affect their usefulness. Emphasis on frills and fancy points will only decrease the opportunity to improve more important productive characteristics. In 1963, one major U.S. artificial insemination company announced that it would no longer make reference to type ratings or show winnings in advertising bulls in their A.I. stud. This was a sound step toward placing total emphasis on productive merit in the dairy industry, but it was withdrawn due to extreme pressures against departing from traditional concepts of evaluation.

Opportunity for Selection and Culling

There are two major considerations which influence the amount of culling and selection possible, namely the reproductive rate and the number of characteristics on which selection is based. Studies indicate that the average cow stays in the milking herd for 4 to 5 lactations which means that we can expect a culling rate of 20 to 25% per year. About one-half of these go out due to poor production and the remainder for other causes. Also, it requires about three pregnancies to produce each female replacement which will eventually complete a lactation. British workers have estimated the rel-

ative opportunity for genetic improvement from emphasizing various selection approaches as follows:

	%
Selection of Bulls as sires of future young bulls	43
Selection of Bulls as sires of future heifer replacements	18
Selection of Cows as dams of future young bulls	33
Selection of Cows as dams of future young heifers	6

The above indicates that emphasis on the male replacements will be about three times as rewarding as emphasis on female replacements. This is mostly a reflection of the larger proportion of heifers which must be retained to meet replacement requirements.

Records

The important records for selection and culling purposes have been milk production and fat per cent. It is likely that the non-fat solids content will assume greater importance in the future. It appears that measuring and analyzing 24 hour yields once each month is nearly as accurate in predicting subsequent lactation yields as is the complete record.

Record Evaluation

In evaluating a dairy production record, one must recognize the effects of certain environmental influences and make allowances for them.

Length of Lactation—Length of lactation is usually standardized to 305 days.

Age of cow at calving—The age of the cow at calving influences her production and is adjusted by placing the record on a Mature Equivalent (M.E.) basis or on a % of Breed Class Average (B.C.A.) system. The M.E. system merely adjusts the records of young or very old cows to what they would be expected to do as mature animals from 6 to 9 years of age. Constant multiplying factors are used for the various age classes and for the different breeds of cattle.

The B.C.A. system is used in Canadian R.O.P. and sets the running average of a breed class (i.e. a particular age group) at 100% and compares any record in the same breed and age group as a % of this average. The B.C.A. system is simple and generally useful in that a particular record is compared to the breed class average as a %. However, it can be misleading in that it also reflects herd and regional differences which are largely environmental. The current use of herd-mate or contemporary comparisons tends to remove the effect of major environmental influences.

Other Environmental Influences—The length of the preceding dry period and the season of freshening influence lactation records as do other environmental effects. Seasonal effects might be removed in a large herd by making comparisons only among records which started in a given six month period.

Herd, Regional and Year Effects—Conditions of management, feeding, weather, etc., vary sufficiently between herds, years and regions such that major errors can be made in selection unless these sources of variation are taken into account.

Table 8 shows that average production of Guernseys and Jerseys in Alberta is slightly below national average and for Ayrshires slightly above national average. However, the number of records for these breeds is relatively small. Alberta Holsteins, on the other hand, produced virtually at the national average. In contrast, Holsteins in British Columbia produced some 1600 lb. more milk than Alberta Holsteins. Since the sires used artificially in B.C. are also used widely in Alberta, Holsteins in these provinces should be genetically similar. The difference in provincial averages may reflect differences in weather, management, nutrition, etc., which should be taken into account when evaluating records from different geographical areas.

Sire Evaluation

Approximately 30% of the dairy cows in Canada are bred artificially, only 25% in Alberta but 75% in British Columbia. Because of the tremendous potential of artificial insemination in dairy cattle improvement, accurate proofs of the real transmitting abilities of bulls are needed. Many methods of expressing a sire proof have been recommended but comparison of a sire's daughters with their contemporaries or herd-mates in several herds is the most reliable estimate of the sire's transmitting ability. Because many of the differences among herds are environmental and because sires have different numbers of daughters in herds producing at various levels, the contemporary or herd-mate comparison offers the most accurate as well as the most practical measure of a sire's worth relative to other sires of his breed.

Selecting bulls from record breaking dams as well as sires with high proving on natural service has given disappointing results. Some of these high records have been made under the very best of care and feeding with the result that the apparent superiority is not transmitted to the progeny. Prospective young sires should be sired by bulls of proven high transmitting ability and from the most productive cows which have been fed and managed on the same basis as their herd-mates. Larger herds generally provide greater opportunity for selection than smaller herds.

Actual production figures, so common on pedigrees, are of very little value for sire selection, especially if there is no indication of the herd average in which the records were made. To make these figures even less useful, one often finds that only the best records of particular animals in the pedigree are listed. In the end, the progeny test is the only reliable guide to a bull's breeding value.

Genetic Defects and Artificial Insemination

In 1968, twelve bulls in Canada each bred over 8000 cows artificially. Two bulls each bred over 25,000 cows. At this latter rate, 100 A.I. sires could service Canada's entire population of 2.5 million dairy cows. Some breeders fear that A.I. will necessarily lead to increases in the spread of deleterious genes. Such fears may not be well grounded unless selection of bulls for A.I. consistently favors bulls with genetic defects.

Let us assume that 100,000 sires would be required to breed Canada's 2.5 million cows under natural service and that 1% of the calves born showed some genetic defect of simple recessive inheritance. In theory, 18% of the parents would be expected to be heterozygous (carriers) for the recessive gene involved. If through A.I. the number of sires could be reduced to 1000 or even to 100, there would still be an expectation of 18% heterozygotes and 1% defective calves unless selection for A.I. markedly favored or discriminated against heterozygous bulls.

Only if the selection of bulls for A.I. consistently favors bulls carrying deleterious genes or, if through A.I., heterozygous bulls consistently sire more progeny than non-carriers, would there be any expectation of any increase in genetic defects through the use of artificial insemination.

Actually, A.I. offers some safeguards against either of these eventualities. Because A.I. sires produce a large number of progeny, genetic defects can be detected more rapidly than under limited natural service. If a sire is proven to carry one or more deleterious genes, the information can be publicized and matings avoided where the dam may also be a carrier, such as when her sire was a known transmitter of the same defect.

Every individual carries genes that are potentially deleterious in particular combinations with other genes or under the wrong environmental circumstances. Dietary deficiencies can induce a wide array of defects in otherwise normal animal populations. Such defects are frequently classified as due to genetic recessives simply on the grounds that neither parent exhibited the trait. In some instances deleterious genes have been demonstrated to enhance fitness when in heterozygous combination with a "normal" counterpart. In fact, the very existence of deleterious and lethal genes indicates that such a situation may be fairly general. In view of these circumstances some caution is urged before culling sires that have produced defective progeny.

If a bull is siring daughters superior in production there seems little reason to discard him simply because he may also be producing some defective calves. By all means, such information should be declared to prospective users but the tolerance and popularity of bulls with negative production proofs poses a far more serious problem to dairy cattle improvement.

Crossbreeding

There has been a general aversion by dairymen to crossbreeding. This may stem in part from the fact that the majority of dairymen in Canada keep Holsteins and it is difficult to improve the milk production in such herds if sires from breeds of lower milk production potential are used in crossbreeding. However, from theoretical considerations, crossbreeding should benefit a commercial dairy producer by favorably influencing fitness traits such as constitutional vigor, survival, reproductive efficiency, hardiness and longevity.

Illinois researchers have reported more than twice the mortality rate in purebreds vs. crossbreds (Table 11). Sixteen of 93 Holsteins, 15 of 54 Guernseys, but only seven of 63 first crosses and

TABLE 11
MORTALITY IN HOLSTEIN, GUERNSEY AND CROSSBRED HEIFERS

	Holstein	*Holstein Male X Guernsey Female*	*Guernsey Male X Holstein Female*	*Guernsey*	*3/4 H*	*3/4 G*
Calf Losses						
Total Born	93	30	33	54	53	48
Total Died	16	2	5	15	3	4
% Died	17.7	6.7	15.2	27.8	5.7	8.3
Cow Losses*						
Total Cows	29	25	27	19	...	...
Total Leaving Herd	9	4	4	8	...	...
% Leaving Herd	31.0	16.0	14.8	42.1	...	...

* Due to reproductive difficulties, disease and death.

seven of 101 backcrosses died as calves. Twenty-three % of 65 purebred females were lost by death or sterility from birth to first calving as compared to only 11% of 63 first crosses.

Of cows which calved at least once, nine of 29 Holsteins (31%) eight of 19 Guernseys (42%) but only eight of 52 first crosses (15%) were lost from the herd due to death and disease before the sixth lactation. There was no difference in level of previous milk production between the dead cows and the survivors—high producers were lost as often as low producers. Thus, opportunity for selection was higher in the crossbred herd. Further, the average cost of bringing a heifer to productive age and the increased cost of replacements would be higher in the purebred herd due to substantially higher mortality at all ages. These crossbred advantages in survival are consistent with those reported in crossbreeding trials with beef cattle and other classes of livestock.

The effects of crossbreeding on milk production are more complex. In most reports, the crossbreds have been superior in milk and fat production to the average of the parent breeds and about intermediate in fat percentage. The results of extensive crossing by the U.S.D.A. are shown in Table 12.

TABLE 12

SUMMARY OF LACTATION RECORDS IN THE BELTSVILLE PROJECT

Generation	*No. of Cows*	*Actual 365, 3X Records*		
		Milk	*Fat*	*Test*
Foundation purebreds	55	10,540	455	4.55
Two-breed crosses	55	13,039	586	4.53
Three-breed crosses	58	13,361	588	4.44
Progeny of three-breed crosses	73	13,174	600	4.58

The breeds involved were Holstein, Jersey, Red Dane and Guernsey. Fat yields showed superiority over both parental breeds. Fat % was about the average of the parental breeds and milk yield was above the average of the parental breeds in all the combinations studied. While the crossbreds produced substantially more milk than the average of the purebred parents and were less variable in performance, the crossbreds did not always exceed the higher producing parent in milk volume.

There seems to be no doubt but that productive capacity of most dairy breeds can be materially improved through crossbreeding with breeds of equal or superior productive merit. The choice of breeds for crossing with the Holstein, however, is not without difficulties. The available breeds for crossing are generally smaller in body size and produce less milk.

Presently, the Guernsey-Holstein crossbreeding experiment at the University of Illinois is in advanced generations of criss-crossing. In the first lactation, the first generation crossbreds produced 2% more milk and 12% more fat than the purebred average. In the second lactation the crossbreds produced 3% less milk and 7% more fat. Considering all lactations, the crossbreds produced 6% less milk but 6% more fat. Comparisons of production with each parent breed were not reported. Body weights at four years of age, however, were 1,408 lb. (Holstein), 1,331 (Guernsey x Holstein), 1,198 (Holstein x Guernsey), and 1,095 (Guernsey). All measures of size in the crossbreds favored those out of Holstein dams. The breeder of Holsteins would thus expect less reduction in size than the average of the entire crossbred group would indicate.

Summaries of various crossbreeding experiments with the Holstein indicate that increases in milk volume by crossbreds over Holsteins cannot generally be expected after the first lactation. The substantial crossbred advantages in durability may make crossbreeding the Holstein herd advantageous but as yet these advantages are either not generally recognized or have not provided sufficient incentive to induce dairymen to crossbreed.

New Breed Development

Increases in productivity from heterosis (hybrid vigor) have been utilized in most classes of farm livestock. If crossing currently available dairy breeds on Holsteins fails to give improvement in milk production in addition to the already reported gains in survival, the development of one or more new breeds specifically for crossing with the Holstein will be required if the substantial benefits of heterosis are to be extended to the dairy industry. One approach would be to combine breeds such as Ayrshire, Guernsey, Brown Swiss, Jersey or others into two-breed or multiple-breed gene pools from which to develop new breeds superior to the parent stocks. Although the possibility of thus achieving new breeds superior to the Holstein has been demonstrated by developmental work in other classes of livestock, the lower milk yields of these parental stocks would make such prospects long term at best.

Another approach would be to include the Holstein in the new breeds by crossing sires of superior transmitting ability for high milk production from the Ayrshire, Brown Swiss, Guernsey and perhaps other breeds on high producing Holstein cows (Fig. 7). The progeny from each of these two-breed combinations would become foundations for separate new breeds. Crossbred sires would be mated to crossbred females within each population and con-

tinuous intermating and intensive selection applied for high production.

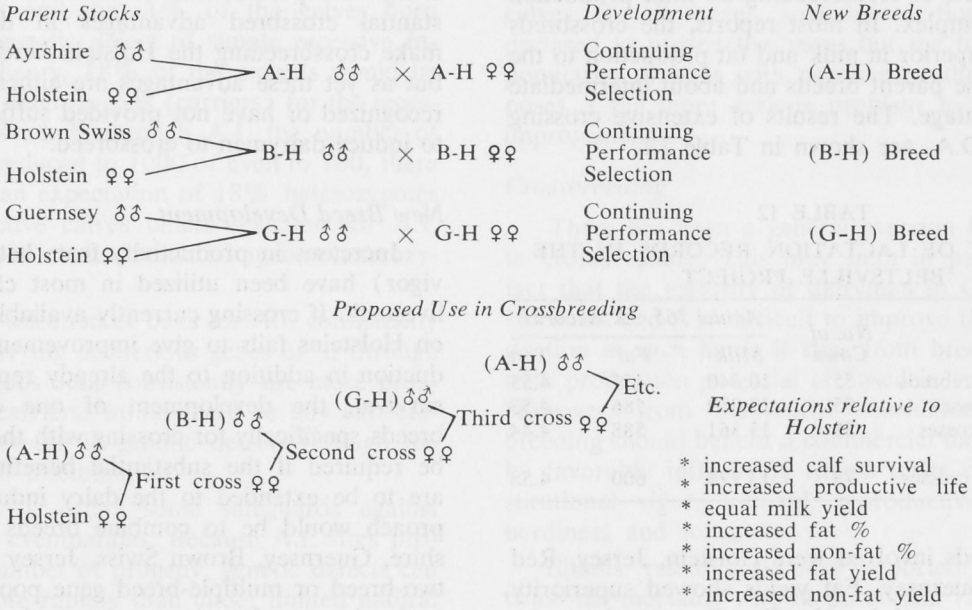
The objective would be to produce new breeds for crossing with the Holstein with expectation of the new breeds approaching the milk yield of the Holstein and the % milk components of the other parent as the result of the selection program. The inclusion of Holstein genes in these new breeds would lead to an expected partial reduction in heterosis when crossed with the Holstein (due to reduced genetic diversity) but would increase the expectation of a higher level of milk production and thus an increased expectancy of crossbreds which would perform above the level of the straightbred Holstein.

The concept is not new. One need look no further than the Lacombe pig which was developed by crossing three breeds followed by intermating and intensive selection. The Lacombe is virtually equal to the better parent (Landrace) in carcass merit and decidedly superior to all parent breeds in growth rate. Lacombe crossbred females are widely used for commercial production.

Other examples can be cited in all other classes of farm livestock. Only dairy cattle breeders among the Canadian livestock industries have made no notable starts toward the application of genetic principles to new breed development. In this regard their counterparts in Latin America, Europe and the U.S.S.R. have shown more flexibility in breaking from traditional breeding practices. Virtually all our knowledge of genetics has been derived in the 20th century. Most of our breeds were derived in the 17th and 18th.

FIG. 7

PROPOSED APPROACH TO DEVELOPMENT AND USE OF NEW DAIRY BREEDS



The following publications are recommended to augment the information given herein. These are obtainable from the Department of Extension, The University of Alberta, Edmonton or from any District Agriculturist.

Alberta Department of Agriculture, Edmonton

Alberta Farm Guide Publication No. 120/20-1	Hay and Pasture Crops for Alberta
Publication No. 11 127-52	Silage in Alberta
Publication No. 410/13-24	Cleaning and Sanitizing Farm Dairy Utensils
Publication No. 11 410/13-14	Milk and Cream Taints and Defects—Causes and Remedies
Publication No. 102	Weed Flavors are Costly to Dairy Farmers
Publication No. 103	Cow Testing and Keeping Cow Records
Publication No. 663-1	Bloat
Publication No. 663-5	Vibriosis and Your Calf Crop
Publication No. 651-1	Dairy Pesticides
Publication No. 173	Quality Milk Pays and Satisfies
Publication No. 410/26	Dairy Herd Improvement Using Artificial Insemination

Canada Department of Agriculture, Ottawa

Publication No. 844	High Quality Milk
Publication No. 1129	Ventilation of Dairy, Poultry and Pig Buildings
Catalogue of Plans	Dairy Cattle Housing and Equipment

University of Alberta, Edmonton

Joint Series Publication No. 410/13 Feeders' Day Reports	Immersion Cleaning of Milking Machines

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